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# **Capilano Treetop Adventures -- Forest Canopy Walkway Bridges**

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# Executive Summary

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The Capilano Suspension Bridge is one of Vancouver's signature tourist attractions. It accommodates up to 750,000 visitors a year for its spectacular views of the canyon and the surrounding forest, which includes majestic 250 year-old Douglas Firs. When the bridge owners found that the heavy volume of pedestrian traffic was damaging the sensitive forest floor they conceived the vision of a new attraction: Treetops Adventure, an elevated forest walkway. McElhanney was retained to help them realize this vision.

McElhanney's challenge was to design a walkway high in the trees that would be accessible to anyone that could climb a few steps, and offer unimpeded views of the treetops without damaging the trees in any way. Working closely with an arborist and a specialty contractor, McElhanney exceeded the objectives of the project by utilizing several design innovations. The result is a unique facility that has generated world-wide attention, won awards, increased attendance by 40%, provided educational opportunities, and enhanced Vancouver's reputation as an attractive destination for environmentally conscious travelers.

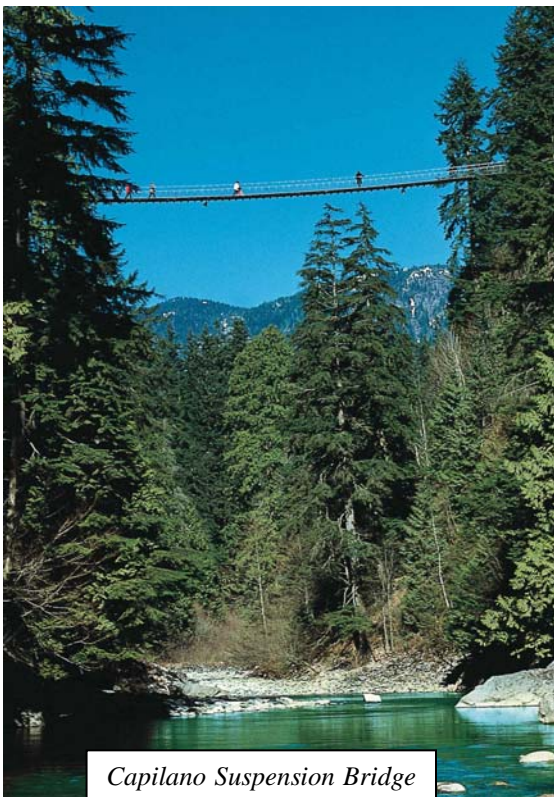
The project consists of a series of seven suspension bridges connecting eight magnificent Douglas Fir trees in a horseshoe configuration. By taking advantage of the natural slope of the canyon lands, visitors are transported up to 30 meters above ground level. Custom-designed friction collars support viewing platforms at each tree without damaging the bark or the delicate tissues beneath. The bridge suspension cables are integrated into the bridge deck design, allowing the structures to blend into the environment without impeding the views.

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## Full Project Description

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Capilano Suspension Bridge is one of Vancouver's signature tourist attractions, accommodating up to 750,000 visitors a year. It was originally constructed in 1889, and completely rebuilt in 1956. With a span of 140 meters suspended some 70 meters above the Capilano River it offers spectacular views of Capilano Canyon below. Since 1993, McElhanney has been providing the owners of the bridge with annual safety inspections and other engineering services relating to repairs, adjustments and maintenance.



*Capilano Suspension Bridge  
originally built in 1889.  
Rebuilt in 1956*

On the west side of the Canyon is an unspoilt forest of Douglas Fir, Sitka Spruce, Yellow Cedar, Western Red Cedar and Western Hemlock. The Douglas Firs are the most impressive of these, with magnificent specimens, over 250 years old, towering up to 70 meters high in a classic rainforest environment - all within minutes of downtown Vancouver. For years, visitors to the bridge have enjoyed walking the forest floor among these living giants. Unfortunately, the heavy pedestrian traffic compacts and degrades the living soils of the forest floor and the plant communities that these soils support. Had this been allowed to continue, the pristine natural environment would have sustained long-term damage.

In response to this risk, the Owners of Capilano Suspension Bridge began to construct wooden boardwalks along the alignments of the forest trails, and this led to the conception of Treetops Adventure – an elevated walkway into the lower reaches of the old growth canopy that would provide visitors with an enhanced and unique rainforest experience, while preserving the delicate forest floor for ever. At this point they hired the project team: McElhanney Consulting Services Ltd. (Art Williams P. Eng.) to carry out the engineering design, working with a Consulting Arborist (Jeremy Gye) and a Specialist Contractor (Marc Luc Lalumière) to help the Owners turn their vision into reality.

## Project Objectives

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The seeds for Treetops Adventure were sown when the Owners of Capilano Suspension Bridge experienced canopy walkways in Australia and in Costa Rica that provided visitors with the thrill of being high among the trees. However, they wanted to improve upon what they had seen in at least four important respects:

- a) Treetops Adventure had to be accessible to people of all ages. The other projects could only be accessed by fairly athletic people able to swing from cables,
- b) Treetops Adventure had to protect the trees from any damage. In the other projects, the structures are attached to the trees with bolts and nails,
- c) Treetops Adventure had to blend into the environment, and offer an unimpeded view of the trees. In the other projects the views are spoiled by a network of cables supporting the structures, and
- d) Treetops Adventure had to be able to accommodate 750,000 visitors per year (over 300 people per hour). The other projects are visited by many fewer people because they are situated in remote areas.

The challenge that faced our project team was therefore to design a unique walkway, different from any other in existence: one that would enable anyone but the most severely handicapped to enjoy a “squirrel’s-eye view” of the forest, without any cables or other structures above eye level, and without harming the trees in any way.



*The bridges transport visitors 30 meters above the forest floor by climbing no more than a dozen steps.*

## Project Solutions & Achievements

The project team developed a design concept that is elegant, economical, practical and environmentally sustainable. They started by selecting eight of the tallest and most magnificent specimens of Douglas fir on the site. They selected trees that would take advantage of the natural slope of the ground to allow a series of seven suspension bridges, connecting one tree to the next in a horseshoe configuration, to transport visitors from ground level to a height of up to 30 meters (the roof of a 12 storey building) above ground, while negotiating a minimum number of steps. The result was that each visitor needs to negotiate only twelve steps to access the first bridge, then five steps at the end of each bridge to access the viewing platforms that surround six of the trees.

The Arborist carefully inspected each tree to ensure that we had selected sound and healthy trees with no visible signs of root damage or rot. The project team procured a precise survey of the location and ground elevation at each tree to provide the design information for the suspension bridges. During the design phase, McElhanney worked closely with the Owner, the Arborist and the Contractor to address a number of cross-disciplinary issues, including:

- The Owner's functional, aesthetic and economic concerns,
- The Contractor's need for constructability, access and availability of materials, and
- The Arborist's advice on the key vulnerabilities of the trees as biological systems and dynamic structures that accommodate loads differently than static columns.

To support the viewing platforms at each tree we designed unique friction collars. Tension bolts on these collars are precisely torqued to generate friction on the tree trunk of 20 pounds per square inch – roughly the pressure the average person can exert by pushing down firmly on a table top with their thumb. Thanks to this design, the platforms can easily support visitors standing shoulder to shoulder on every platform and every bridge, without causing any damage

*Treetops Adventure consists of 7 suspension bridges connecting 6 viewing platforms that surround 250-year old Douglas Fir Trees*





to the sensitive tree bark, or the delicate tissues beneath. Not a single saw-cut, bolt or nail into any tree was required to construct this design. We believe this to be a world first.



*Combined with ground level boardwalks, Treetops Adventure is designed to protect the fragile forest floor.*

To construct suspension bridges without any structures or cables above eye-level we created another design innovation: the suspension cables for each bridge are integrated into the deck. The side-rails are woven with safety netting and the bridge decks built of recycled cedar planks, so that when viewed from above or below, the bridges blend with the surrounding forest. The only materials used that are not completely integrated into the bridges are guys installed to anchor three of the trees to adjacent trees to balance eccentric forces imposed by the bridges. These guys are located below eye-level for visitors standing on the bridges.

The delicate environment demanded strict conditions for the construction and the materials that could be used for this project. As a result the project was constructed entirely by hand. Most of the construction was built off site and lifted into place using a system of ropes and pulleys to prevent damage to the trees and forest floor.

Treetops Adventure opened in May 2004. Since that date, the number of visitors to Capilano Suspension Bridge has increased by 40%. Articles extolling its virtues as a tourist attraction, and lauding its engineering innovation have appeared in newspapers throughout North America, and it has attracted attention from around the world. At its 2004 National Awards for Tourism Excellence, the Tourism Industry Association of Canada presented its Innovator of the Year Award to Capilano Suspension Bridge for the Treetops Adventure project. At its 2005 awards gala, the Consulting Engineers of BC honoured McElhanney with an Award of Merit for this project.

## Technical Excellence & Innovation

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As far as we are aware, Treetops Adventure is completely unique. It is the only project of its kind that offers almost universal accessibility and an unimpeded view of the upper forest storey without having damaged a single tree.

The friction collars and bridge suspension cables are all completely adjustable; McElhanney have a contract in place to monitor the trees on a regular basis and engineers carry out periodic safety inspections, and will make fine adjustments to the cable turnbuckles and friction collar tension bolts to accommodate the trees as they continue to grow. The first adjustments are expected to be necessary in seven to ten years.

*Braided polyethylene guys dampen wind oscillations and balance eccentric loads on the trees.*



The guys that were used to anchor viewing-platform trees to adjacent trees are composed of double-braided polyester, which is able to absorb energy by stretching, then slowly returning to its original length. The adjacent trees are typically smaller than the viewing-platform tree, which means that in windy weather they sway with different frequencies and amplitudes; if steel cables had been used to connect two trees of different sizes, they would experience a shock restraint when swaying away from each other, and damage the trees at the collars. By absorbing energy, the double-braided polyester is able to dampen the swaying without harming the trees. This phenomenon is not a concern for the steel cables supporting the seven

suspension bridges, because sag is integral to their design, and even when the trees sway away from each other there is sufficient slack to avoid increasing the forces on the friction collars.



McElhanney's surveyors have established precise survey control points at the site and are making periodic measurements of tree shift and tilt; to date, the largest tree movement measured has been 7 millimeters – which is well within the tolerance that the trees are able to accommodate.



*Friction collars gently support the platforms and bridges without harming the trees.*



# **Environmental, Economic, and Social Sustainability & Aesthetics**

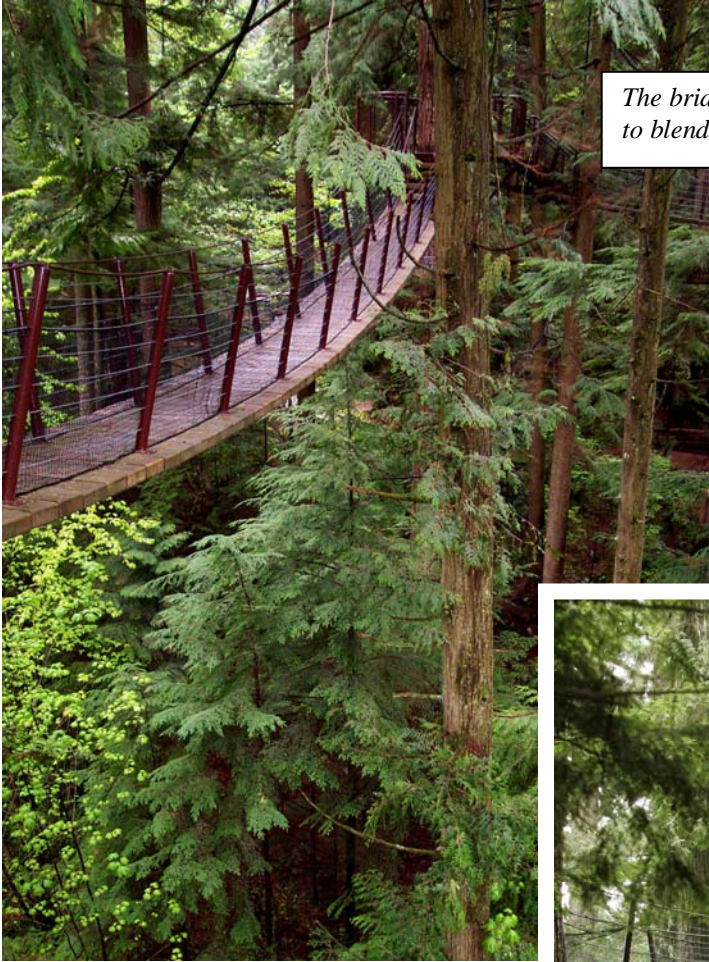
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The World Tourism Organization defines Sustainable Tourism as “tourism which actively fosters appreciation and stewardship of the natural, cultural and historic resources and special places by local residents, the tourism industry, governments and visitors. It is tourism which can be sustained over the long term because it results in a net benefit for the social, economic, natural and cultural environments of the area in which it takes place.” This definition has also been adopted by Parks Canada.

The Capilano Suspension Bridge Treetops Adventure project clearly meets the definition of Sustainable Tourism. It is in the nature of the human race that we long for the experience of climbing trees; for most children the concept of a tree-house has a magical quality. Treetops Adventure offers access to this experience to an unprecedented degree for children, adults and seniors alike.

Capilano Suspension Bridge has a team of naturalists that greet visitors to Treetops Adventure and offer them an educational experience. By sharing stories and answering questions about the forest and tree canopy, visitors gain an increased appreciation for our natural environment. They leave Treetops with the desire to learn more about the environment, and to contribute to efforts to protect our majestic forests and their ecosystems for future generations.

The project provides protection for the sensitive forest floor, blends visually with the surrounding forest, and was accomplished without a single nail, bolt or saw-cut penetrating the fragile tree bark. Thanks in part to the ingenuity of McElhanney’s engineers, the project is exceeding its objectives and demonstrates the expanding role of the engineer in today’s society.



*The bridges and platforms are designed to blend into the rainforest environment.*



*Treetops Adventure was designed to be safely accessible to visitors of all ages.*