Photo 53. The timber towers were sheared at the base by floodwater driven debris. *Photo courtesy of Mr. Tibor Latincsics.*

Photo 54. Hastings Bridge walkway remains flung downstream. *Photo courtesy of Mr. Tibor Latincsics.*

Mountains. In this case, the floodwaters picked up an old logging bridge and carried it downstream. The Hastings Trail Bridge was a 180-foot suspension bridge with a 17-foot clearance to the normal water level of the Wild River. However, the logging bridge snagged on the low hanging wind guys of the bridge. The impact force and hydrodynamic loads sheared the bridge towers at their base. Twenty-thousand pounds of buried concrete deadmen were plucked out of the soil and flung 200 feet downstream. Proper clearance to floodwater is critical!

The Hastings Creek Bridge was reconstructed in the Fall of 1997, to USDA Forest Service specifications. The new 180-foot bridge has a clear travel lane dimension of 5.5 feet to allow snowmobile traffic. There is a paved road directly to the site. The original tower foundations were reused. The replacement cost for the bridge superstructure by a professional contractor was $142,675.

Identifying the 100-Year Flood Level

Identification of the 100-year flood level can be made one of several ways. The project engineer investigated every option. Within the State of New Jersey, most major watercourses have had a hydrologic and hydraulic study performed by the NJDEP Flood Study Section. This was the first place to look to determine the 100-year flood level. Studied watercourses are known as delineated watercourses, and they have recognized 100-year flood levels. The Pochuck Creek is probably the largest non-delineated watercourse in New Jersey. There is no NJDEP recognized flood level data. The second step was to check the Federal Emergency Management Agency (FEMA) Flood Insurance maps. The Pochuck Creek is also an unstudied FEMA watercourse, although the FEMA maps indicated a 100-year flood elevation of 400 feet above sea level based on the highwater mark of floods dating to 1937. The Army Corps of Engineers did not have any specific flood data for the Pochuck Creek.

The last resort was to perform a Hydraulic Engineering Center-II (HEC) analysis. A downstream gauging station provided the stream flows for the 2-, 10-, 25-, and 100-year storms. The HEC-II computer analysis models stream flow through a channel and overbank reach as steady open channel flow. Among the results are the water surface elevation and velocity of flow. The project engineer performed this analysis to check if the 100-year flood elevation of 400 feet identified by the historical highwater marks was realistic. The results were very interesting. If one excluded the log jams in the HEC-II model, the 100-year flood level was much below elevation 400. With the log jams modeled, the flood level rose. The elevation of 400 feet was used as the design and regulatory standard.

The Main Cables – Catenary Cables

Thus far, the main cables have been referred to as catenary cables. For a cable to assume the shape of a catenary, the load on the cable must be uniformly distributed. Under the spaced suspender loading, the shape is closer to a parabola. The difference between the two is very slight. Since the equation for a parabola is easier to work with, most engineers use the parabola equation in the design of simple suspension bridges. Since this case study is presented as a planning document, not an engineering text, the author has refrained from including design equations. However presenting some basic wire rope equations for a single-span suspension bridge at this point has some value (see Figure 9).

- e = sag of catenary cable.
- ℓ = the span or horizontal distance from center of each cable saddle to opposite cable saddle. In the case of the Pochuck Quagmire Bridge, the as-built distance is 110.20 feet.
- W = the total live and dead load of the bridge expressed as load per unit length of span. Assumes backstays have no suspender loads.

Length of a uniformly loaded cable between two supports at equal elevation:

$$L = \ell\left(1 + \left[\frac{8}{3}\right]\frac{e^2}{\ell^2} - \left[\frac{32}{5}\right]\frac{e^4}{\ell^4} + \left[\frac{256}{7}\right]\frac{e^6}{\ell^6}\right)$$

The maximum tension in the cable is immediately before the cable saddle:

$$T_{saddle} = \left[\frac{W}{8e}\right]\sqrt{l^4 + 16e^2\ell^2}$$

The minimum tension in the cable is at the midpoint sag lowpoint of the cable: $T_{Lowpoint} = \frac{w\ell^2}{8e}$

Tension at a given point B: $T_B = w \big/ 8e\sqrt{\ell^4 + 64e^2 - y^2}$

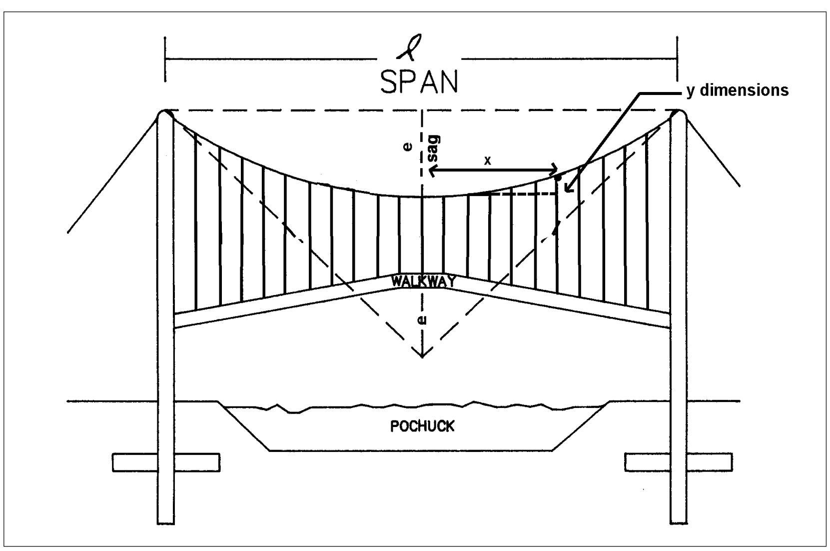

Figure 9. Nomenclature for wire rope equations.

Figure 10 provides freebody vector diagram for the Pochuck Quagmire Bridge cable saddles and tower tops. The identified loads were calculated utilizing the previous equations, bridge loads, and bridge dimensions. The freebody vector diagram illustrate the important design element, that where practical, the cable departure angle on either side of the cable saddle should be equal. Equilibrium is easier to obtain if the angles are equal. If the departure angles are not equal, additional loads are transferred to the backstay and tower. In the Pochuck Quagmire