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Techniques of Water-Resources Investigations
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Chapter A21

STREAM-GAGING CABLEWAYS

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[1]This manual is a revision of "Measurement of Time of Travel and Dispersion in Streams by Dye Tracing," by E.F. Hubbard, F.A. Kilpatrick, L.A. Martens, and J.F. Wilson, Jr., Book 3, Chapter A9, published in 1982.

[2]Spanish translation also available.

TWRI 3–B3.   Type curves for selected problems of flow to wells in confined aquifers, by J.E. Reed. 1980. 106 pages.

TWRI 3–B4.   Regression modeling of ground-water flow, by Richard L. Cooley and Richard L. Naff. 1990. 232 pages.

TWRI 3–B4, Supplement 1. Regression modeling of ground-water flow—Modifications to the computer code for nonlinear regression solution of steady-state ground-water flow problems, by R.L. Cooley. 1993. 8 pages.

TWRI 3–B5.   Definition of boundary and initial conditions in the analysis of saturated ground-water flow systems—An introduction, by O. Lehn Franke, Thomas E. Reilly, and Gordon D. Bennett. 1987. 15 pages.

TWRI 3–B6.   The principle of superposition and its application in ground-water hydraulics, by Thomas E. Reilly, O. Lehn Franke, and Gordon D. Bennett. 1987. 28 pages.

TWRI 3–B7.   Analytical solutions for one-, two-, and three-dimensional solute transport in ground-water systems with uniform flow, by Eliezer J. Wexler. 1991. 193 pages.

TWRI 3–C1.   Fluvial sediment concepts, by H.P. Guy. 1970. 55 pages.

TWRI 3–C2.   Field methods of measurement of fluvial sediment, by H.P. Guy and V.W. Norman. 1970. 59 pages.

TWRI 3–C3.   Computation of fluvial-sediment discharge, by George Porterfield. 1972. 66 pages.

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TWRI 5–A2.   Determination of minor elements in water by emission spectroscopy, by P.R. Barnett and E.C. Mallory, Jr. 1971. 31 pages.

TWRI 5–A3.[3]   Methods for the determination of organic substances in water and fluvial sediments, edited by R.L. Wershaw, M.J. Fishman, R.R. Grabbe, and L.E. Lowe. 1987. 80 pages.

TWRI 5–A4.[4]   Methods for collection and analysis of aquatic biological and microbiological samples, by L.J. Britton and P.E. Greeson, editors. 1989. 363 pages.

TWRI 5–A5.   Methods for determination of radioactive substances in water and fluvial sediments, by L.L. Thatcher, V.J. Janzer, and K.W. Edwards. 1977. 95 pages.

TWRI 5–A6.   Quality assurance practices for the chemical and biological analyses of water and fluvial sediments, by L.C. Friedman and D.E. Erdmann. 1982. 181 pages.

TWRI 5–C1.   Laboratory theory and methods for sediment analysis, by H.P. Guy. 1969. 58 pages.

TWRI 6–A1.   A modular three-dimensional finite-difference ground-water flow model, by Michael G. McDonald and Arlen W. Harbaugh. 1988. 586 pages.

TWRI 6–A2.   Documentation of a computer program to simulate aquifer-system compaction using the modular finite-difference ground-water flow model, by S.A. Leake and D.E. Prudic. 1991. 68 pages.

TWRI 6–A3.   A modular finite-element model (MODFE) for areal and axisymmetric ground-water-flow problems, Part 1: Model Description and User's Manual, by L.J. Torak. 1993. 136 pages.

TWRI 6–A4.   A modular finite-element model (MODFE) for areal and axisymmetric ground-water flow problems, Part 2: Derivation of finite-element equations and comparisons with analytical solutions, by R.L. Cooley. 1992. 108 pages.

TWRI 6–A5.   A modular finite-element model (MODFE) for areal and axisymmetric ground-water-flow problems, Part 3: Design philosophy and programming details, by L.J. Torak. 1993. 243 pages.

TWRI 6–A6.   A coupled surface-water and ground-water flow model (MODBRANCH) for simulation of stream-aquifer interaction. 1994. 90 pages.

TWRI 7–C1.   Finite difference model for aquifer simulation in two dimensions with results of numerical experiments, by P.C. Trescott, G.F. Pinder, and S.P. Larson. 1976. 116 pages.

TWRI 7–C2.   Computer model of two-dimensional solute transport and dispersion in ground water, by L.F. Konikow and J.D. Bredehoeft. 1978. 90 pages.

TWRI 7–C3.   A model for simulation of flow in singular and interconnected channels, by R.W. Schaffranek, R.A. Baltzer, and D.E. Goldberg. 1981. 110 pages.

TWRI 8–A1.   Methods of measuring water levels in deep wells, by M.S. Garber and F.C. Koopman. 1968. 23 pages.

TWRI 8–A2.   Installation and service manual for U.S. Geological Survey monometers, by J.D. Craig. 1983. 57 pages.

TWRI 8–B2.   Calibration and maintenance of vertical-axis type current meters, by G.F. Smoot and C.E. Novak. 1968. 15 pages.

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[3]This manual is a revision of TWRI 5–A3, "Methods of Analysis of Organic Substances in Water," by Donald F. Goerlitz and Eugene Brown, published in 1972.

[4]This manual supersedes TWRI 5–A4, "Methods for collection and analysis of aquatic biological and microbiological samples," edited by P.E. Greeson and others, published in 1977.

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METRIC CONVERSION FACTORS

Multiply inch-pound	By	To obtain metric unit
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
square foot (ft²)	0.09294	square meter
cubic foot (ft³)	0.02832	cubic meter
cubic yard (yd³)	0.7646	cubic meter
pound, avoirdupois (lb)	0.4536	kilogram
pound, force (lbf)	4.4482	newton
foot-pound (ft·lb)	1.3558	newton meter
pound per square inch (lb/in²)	6.895	kilopascal
pound per cubic foot (lb/ft³)	16.01846	kilogram per cubic meter

GLOSSARY OF TERMS

[The following terms are defined as they apply to stream-gaging cableway system]

A-frame. A structure to elevate and support a cable.

Anchor. A structure connected to end of cable to hold cable in place under tension. Usually concrete or rock.

Area, metallic. Sum of the cross-sectional areas of all the wires in a wire rope or strand.

Backstay. A wire rope guy used to support an A-frame, or other support structure, leading from the top of the support to an anchorage.

Breaking strength. The ultimate load at which a tensile failure occurs in the sample of wire rope being tested. (Note: The term "breaking strength" is synonymous with actual strength.)

(1) **Minimum acceptance strength** is that strength that is 2 1/2 percent lower than the catalog or nominal strength. This tolerance is used to offset variables that occur during sample preparation and actual physical test of a wire rope.

(2) **Nominal strength** is the published (catalog) strength calculated by a standard procedure that is accepted by the wire rope industry. The wire rope manufacturer designs wire rope to this strength, and the user should consider this strength when making design calculations.

Bridge socket. A wire rope or strand end termination made of forged or cast steel that is designed with baskets—having adjustable bolts—for securing rope ends. There are two styles: (1) the **closed type** has a U-bolt with or without a bearing block in the U of the bolt and (2) the **open type** has two eyebolts and a pin.

Bright rope. Wire rope fabricated from wires that are not coated.

Cable. A term loosely applied to wire rope, wire strand, and electrical conductors. In the context of a USGS stream-gaging cableway, it refers to the system's main support rope for cable-car operation.

Cableway. Aerial conveying system for transporting personnel and equipment along a suspended cable above a river.

Catenary. A curve formed by a strand or wire rope when supported horizontally between two fixed points; for example, the main spans on a cableway.

Certification. Documentation provided by manufacturer that demonstrates that wire rope meets minimum acceptance strength.

Circumference. Measured perimeter of a circle that circumscribes either the wires of a strand or the strands of a wire rope.

Clip. Fitting for clamping two parts of wire rope to each other.

Concrete anchor. A large block of concrete used to hold a cable in place under tension.

Constructional stretch. The stretch that occurs when the rope is tensioned. It is due to the helically laid wires and strands creating a constricting action that compresses the core and generally brings all of the rope's elements into close contact.

Core. The axial member of a wire rope about which the strands are laid.

Corrosion. Chemical decomposition of the wires in a rope through the action of moisture, acids, alkalies, or other destructive agents.

(1) **Light corrosion.** Rust showing without pitting of the material. Strength loss is less than 1 percent.

(2) **Mild corrosion.** Rust with minor pitting; less than 5 percent surface pitted. Strength loss is less than 5 percent.

(3) **Moderate corrosion.** Rust showing, with 10 to 30 percent of surface pitted. Strength loss is less than or equal to 10 percent.

(4) **Severe corrosion.** Rust showing, with 30 to 60 percent of the surface pitted. Strength loss exceeds 10 percent and possibly is as high as 25 percent.

(5) **Extreme corrosion.** Rust showing, with 100 percent of the surface pitted; no original surface remaining between pits. Strength loss in many cases exceeds 50 percent.

Design factor. In a wire rope, the ratio of the nominal strength to the total working (design) load.

Design load. Nominal (catalog) strength divided by the design factor. Also known as **Working load.**

Diameter. A line segment that passes through the center of a circle and whose end points lie on the circle. As related to wire rope, it is the diameter of a circle that circumscribes the wire rope.

Dog-leg. Permanent bend or kink in a wire rope caused by improper use or handling.

End termination. The treatment at the end or ends of a length of wire rope, usually made by forming an eye or attaching a fitting, designed to be the permanent end termination on the wire rope that connects it to the load or anchor.

Extra extra improved plow steel rope. A specific wire rope grade.

Extra improved plow steel rope. A specific wire rope grade.

Factor of safety. In the wire rope industry, term originally used to express the ratio of nominal strength to the total working load. The term is no longer used because it implies a permanent existence for this ratio when, in actuality, the rope strength begins to reduce the moment it is placed in service. See **Design factor.**

Fatigue. As applied to wire rope, term usually referring to the process of progressive failure resulting from the bending of individual wires. These fractures may and usually do occur at bending stresses well below the ultimate strength of the material; it is not an abnormality although it may be accelerated due to conditions in the rope such as corrosion.

Fiber core. Cord or rope of vegetable or synthetic fiber used as the axial member of a rope.

Filler wire. Small spacer wires within a strand that help position and support other wires. Also the name for the type of strand pattern using filler wires.

Fitting. Any functional accessory attached to a wire rope.

Galvanized. Zinc coating for corrosion resistance.

Galvanized rope. Wire rope made of galvanized wire.

Galvanized strand. Strand made of galvanized wire.

Galvanized wire. Zinc-coated wire.

Grade. Wire rope or strand classification by strength and (or) type of material, such as improved plow steel, type 302 stainless, phosphor bronze. It does not imply a strength of the basic wire used to meet the rope's nominal strength.

Guy line. See **Backstay.**

Improved plow steel rope. A specific grade of wire rope.

Independent wire rope core (IWRC). A wire rope used as the axial member of a larger wire rope.

Inner wires. All wires of a strand except the outer or cover wires.

Lay. (1) The manner in which the wires in a strand or the strands in a rope are helically laid or (2) the distance measured parallel to the axis of the rope (or strand) in which a strand (or wire) makes one complete helical convolution about the core (or center). In this connection, lay is also referred to as **Lay length** or **Pitch.**

Lay, types.

    (1) **Right lay.** The direction of strand or wire helix corresponding to that of a right-hand screw thread.

    (2) **Left lay.** The direction of strand or wire helix corresponding to that of a left-hand screw thread.

    (3) **Cross lay.** Rope or strand in which one or more operations are performed in opposite directions. A multiple operation product is described according to the direction of the outside layer.

    (4) **Regular lay.** The type of rope wherein the lay of the wires in the strand is in the opposite direction of the lay of the strand in the rope. The crowns of the wires appear to be parallel to the axis of the rope.

(5) **Lang lay.** The type of rope in which the lay of the wires in the strand is in the same direction as the lay of the strand in the rope. The crowns of the wires appear to be at an angle to the axis of the rope.

(6) **Alternate lay.** Lay of a wire rope in which the strands are alternately regular and lang lay.

(7) **Alberts lay.** An old, rarely used term for lang lay.

(8) **Reverse lay.** Another term for alternate lay.

(9) **Spring lay.** Not definable as a unique lay; more properly, it refers to a specific wire rope construction.

Lay length. See **Lay** (2).

Messenger cable. Galvanized rope used as support for aircraft warning markers or other special purposes.

Modulus of elasticity. Mathematical quantity expressing the ratio, within the elastic limit, between a definite range of unit stress on a wire rope and the corresponding unit elongation.

Nominal strength. Values calculated by standardized, industry-accepted procedures. Also known as **Catalog strength.** Designers should base calculations on these values.

Prestressing. An incorrect reference to **Prestretching.**

Prestretching. Subjecting a wire rope or strand to tension prior to its intended application for an extent and over a period of time sufficient to remove most of the **Constructional stretch.**

Rated capacity. The load that a new wire rope may handle under given operating conditions and at an assumed **Design factor.**

Regular lay rope. See **Lay, types.**

Reserve strength. The strength of a rope exclusive of the outer wires.

Reverse lay. See **Lay, types.**

Right lay. See **Lay, types.**

Safety factor. See **Design factor.**

Safe working load. Potentially misleading term, now in disfavor. Essentially, it refers to that portion of the nominal rope strength that can be applied either to move or to sustain a load. It is misleading because it is valid only when the rope is new and the equipment is in good condition. See **Rated capacity.**

Sag. (1) The sag of a rope in a span, usually measured at midspan as the distance from the chord joining the tops of the two supports or (2) any deviation from a straight line.

Seize. To make a secure binding at the end of a wire rope or strand with **Seizing wire** or other means.

Seizing wire. A wire for seizing. See **Seize.**

Shackle. A U- or anchor-shaped fitting with pin.

Sheave. A grooved pulley for wire rope.

Socket. A type of end termination that provides attachment to an anchor or load. The most common types are—

(1) **Poured zinc (spelter).** Molten zinc is used to bond the wire rope to the socket.

(2) **Poured resin.** Thermo-set resin is used to bond the wire rope to the socket.

(3) **Swaged.** Mechanical force is used to forge or press the socket tightly around the socket. Sockets may be closed, having one extending ear or bail with a hole or opening for attachment, or open, having two extending ears or bails with a hole or opening for attachment. Usually two cables may be attached if one has a closed and the other has an open socket. See **Bridge socket.**

Strand. A plurality of round or shaped wires helically laid about an axis.

Stress. The force or resistance within any solid body against alteration of form; in the case of a solid wire, the load on the rope divided by the cross-sectional area of the wire.

Stretch. The elongation of a wire rope under load.

Structural strand. A plurality of wires formed as a single strand, also known as **Tramway track strand** or **Bridge strand**.

Thimble. Grooved metal fitting to protect the eye or fastening loop of a wire rope.

Track cable. On an aerial conveyor, it is the suspended wire rope or strand along which load carriers move.

Turnbuckle. A right and left screw link to tighten a cable.

U-bar. A U-shaped iron bar embedded in concrete or rock to which a cable is attached.

Wire. (1) **Round**, a single, continuous length of metal, with a circular cross section that is cold-drawn from rod, or (2) **Shaped**, a single, continuous length of metal with a noncircular cross section that is either cold-drawn or cold-rolled from rod.

Wire rope. A plurality of wire strands helically laid about an axis.