McMicken Dam Fissure Risk Zone Remediation
Tape and Rod Extensometer Measurement Instructions
Ground Deformation Monitoring
Contract FCD 2005C005, Work Assignment No. 1

Submitted to:

Flood Control District of Maricopa County
Phoenix, Arizona

Submitted by:

AMEC Earth & Environmental, Inc.
Tempe, Arizona

June 29, 2006

AMEC Job No. 5-117-001099
Letter No. 1

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Michael D. Greenslade, P.E.
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009-6399

Dear Mr. Greenslade:

Re: McMicken Dam Fissure Risk Zone Remediation
Tape and Rod Extensometer Measurement Instructions
Ground Deformation Monitoring
Contract FCD 2005C005, Work Assignment No. 1

Transmitted herewith are four paper copies of the McMicken Dam Fissure Risk Zone Remediation Tape and Rod Extensometer Measurement Instructions. The instructions detail equipment required, step-by-step set up and measurement procedures, and data analysis.

Please do not hesitate to contact us if you have any questions concerning this report.

Respectfully submitted,

AMEC Earth & Environmental, Inc.

Brett A. Howey, P.E.
Project Engineer

Reviewed by:

Daniel N. Fréchette, Ph.D., P.E.
Geotechnical Engineer

c: Addressee (4)

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TABLE OF CONTENTS

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ATTACHMENT A

TAPE EXTENSOMETER MEASUREMENT INSTRUCTIONS

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TAPE EXTENSOMETER MEASUREMENT INSTRUCTIONS

Prior to initiation of measurement AMEC recommends that the person conducting the measurements is properly trained by someone experienced in the collection of tape extensometer measurements at the dam site. The precision of the instrument will depend to a large degree on the skill of the operator in achieving a consistent and repeatable tape tension.

The following instructions shall be read in their entirety before initiation of any measurements.

Equipment

The following equipment is required for tape extensometer measurement:

(1) 4 existing stainless steel Extensometer Extender units marked A, B, C, and D, with each having 4 hex-head bolts (see Figure 1)
(2) 9/16" socket and ratchet wrench
(3) FCDMC owned 100 foot long Geokon 1610 tape extensometer measuring device
(4) FCDMC owned Fluke 51 II Thermometer
(5) FCDMC owned Fluke 80PK-8 Thermocouple

Extension Unit Set Up

The following procedure shall be followed to properly position each extension unit:

(1) Each extension interior shall be examined for obstructions or excess dust. Clean out if necessary.
(2) Remove the plastic valve box covers off each tape extensometer location. Be on the look out for snakes, bees, scorpions, etc. within the box.
(3) Clear any loose dirt or obstructions on the top of the steel monument.
(4) Slide the letter corresponding extension (example 'A' extender must go with 'A' named referenced monument – **VERY IMPORTANT**) over the tape extensometer monument with the beveled monument edge opposite the bolts (Detail 1).
(5) Confirm extension has slid over monument fully and the stop bar in the extension is resting on the monument top.
(6) Tighten top 2 bolts to snug – evenly alternating tightening from one to the other.
(7) Tighten bottom 2 bolts to snug – evenly alternating tightening from one to the other.
(8) Tighten top 2 bolts completely (should take 1/8 to 1/4 turn) – evenly alternating tightening from one to the other. DO NOT over tighten, over tightening may cause bolts to penetrate into steel monument causing inaccurate readings.
(9) Tighten bottom 2 bolts completely (should take 1/8 to 1/4 turn) – evenly alternating tightening from one to the other.

Measurement Sequence

Four (4) sequential tape extensometer monuments should be selected starting at one end of an array and working to the other. The distance between each monument will be measured twice in the sequence.

An example sequence is as follows:

(1) TE1A ⇒TE2B ⇒TE3C ⇒TE4D then measure back towards TE1A
(2) TE4D ⇒TE3C ⇒TE2B ⇒TE1A

Repeat measurement sequence for the remaining tape extensometer monuments.

Measurement Procedures

The following steps reference TE1A through TE4D as an example.

(1) Note: Measurements during windy periods should be avoided. Measurements acquired during the early morning hours when winds are calmer is preferred. Acquisition of measurements should be stopped when movement of the tape does not allow for stabilization of the reading. The experience of the tape extensometer reader is important in identifying excessive wind conditions.
(2) Hook up tape extensometer tape with zero (0 foot) end hooked on the extender eyelet of TE2B.
(3) Walk slowly towards monument TE1A releasing the tape extensometer tape and then hook other end on the extender eyelet of TE1A.
(4) Turn tape extensometer *Power* "on", making sure that the display reads 0.00 mm, (0.00 inches), when the winding handle is turned fully clockwise until it will turn no more - it will come to a natural stop, **do not force the winding handle**. This action is called "home". If the reading on the digital gage does not show 0.00 inches, refer to Geokon manufacturer's instructions.
(5) Turn tape tensioning/winding handle counterclockwise moving the slide bar out to approximately ¼ to ½ inch (6 to 12 mm) beyond the previous reading.
(6) Hold tape extensometer firmly and reel excess tape in with the tape reel handle, to prevent damage to the tape.
(7) By hand, pull on the tape to reduce slack as much as practical.
(8) Place the appropriate punched hole over the locating pin and secure in place by sliding the slotted clip all the way over the tape and pin. Use previous reading as a guide.
(9) Place the Fluke thermometer and thermocouple in the shade that ones body provides while taking the tape reading to keep them out of the sun.

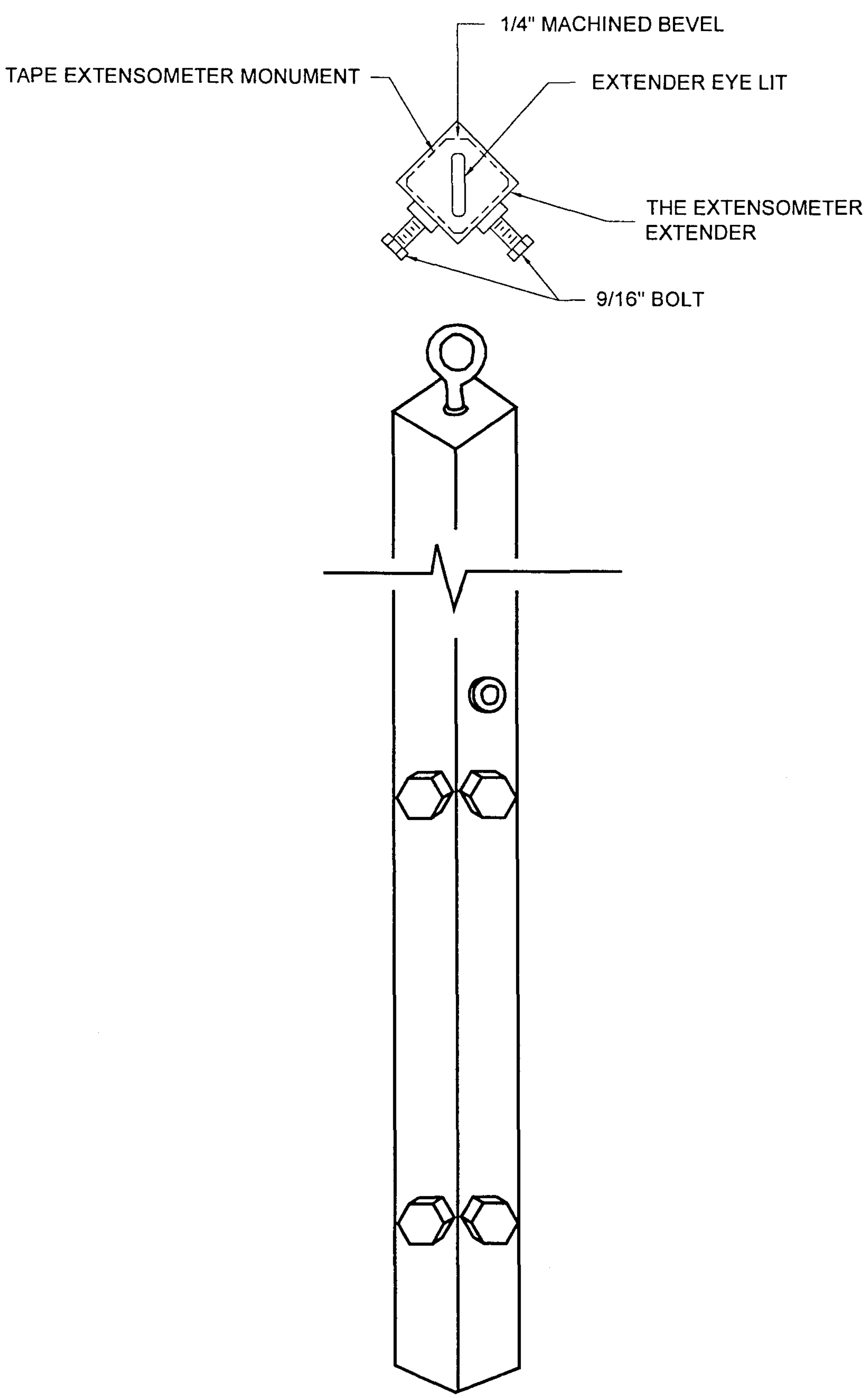
(10) Toggle thermometer *Power* "on" then "off" and then "on" again.
(11) Set thermometer to "Max Hold"
(12) Follow Sections 3.2 and 3.3 of the Geokon manufacturer's instructions for taking readings. Keep *Power* "on" when completed until instructed within these procedures to *Power* "off". Retain the measurement by memory and quickly go to the next step.
(13) Once the reading has been taken, quickly attach the Fluke thermocouple directly to the tape making sure it is connected to a length of tape that has not been shaded from the sun.
(14) Record the tape reading on the standard data sheet.
(15) Record the temperature on the standard data sheet.
(16) After tape measurement is complete slide bar back out, fully taking the tape off the secure pin, maintaining *Power* "on". It is not critical to home everything or extend the slide bar completely back out. It is critical to maintain *Power* "on" to avoid disruption of the instrument zeroing.
(17) Reel up tape slowly being careful to not crimp or damage tape during reeling. The tape will become dirty, cleaning with a towel while reeling will be necessary.
(18) Maintain *Power* "on" through the entire process of measuring 4 sequential monument arrays.
(19) After each monument has been measured, "home" everything making sure the instrument reads 0.00 mm in the digital readout.
(20) Repeat steps 1 through 19 (except step 4, *Power* will already be "on") for the remaining measurements of the group of 4 sequential monuments.
(21) *Power* "off" the tape extensometer.
(22) Move instrument to next sequence of monuments.
(23) Repeat all steps to measure remaining project monuments.

Data Analysis

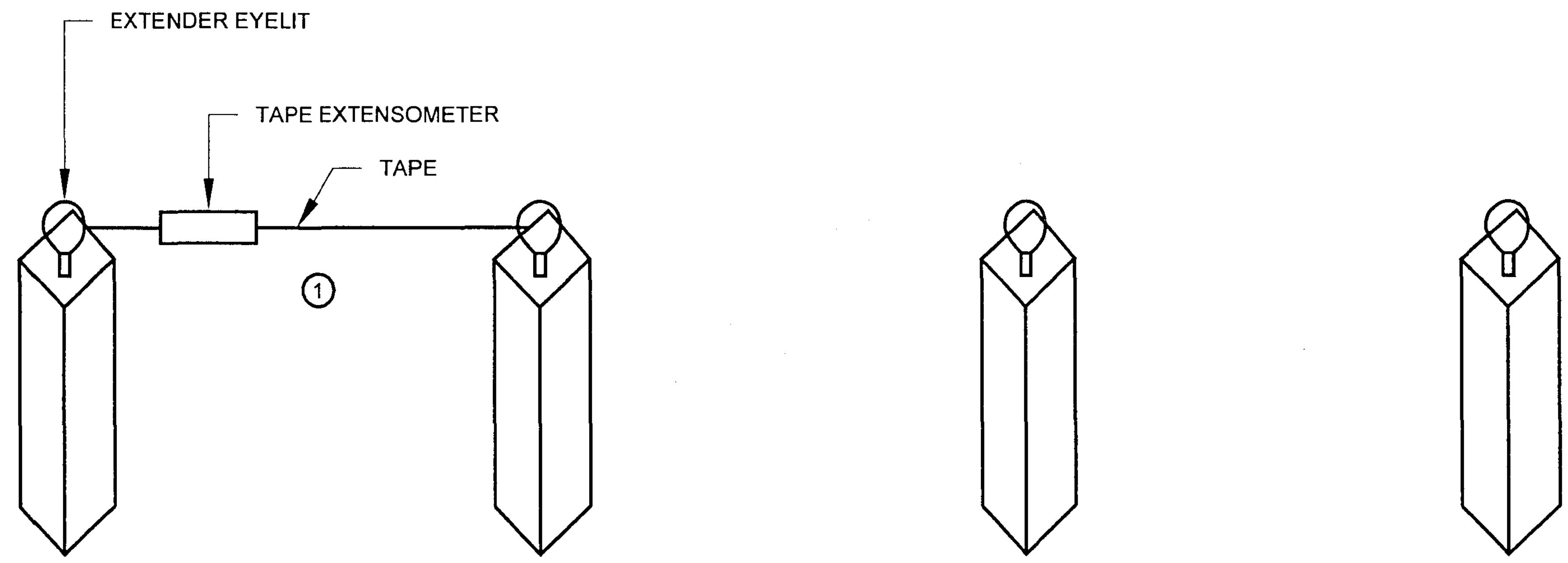
(1) Enter data recorded on data collection sheets into tape extensometer data analysis spreadsheet.
(2) The spreadsheet corrects each reading for temperature based on the following expression:

$$MF_c = \left[\left(\left(MF_{ft} * 12\right) + MF_{in}\right)K\left(T_o - 80\right)\right] + MF_{in}$$

MF_c = field measurement corrected (in)
MF_{ft} = whole increment of field measurement (ft)
MF_{in} = foot fraction increment of field measurement (in)
T_o = field tape temperature in degrees (°F)
K = coefficient of thermal expansion (in/in/°F) = 6.45×10^{-6}



DETAIL - 1



DETAIL - 2 - TYPICAL TAPE EXTENSOMETER SETUP

JOB NO.	5-117-001099	EXTENSOMETER DETAILS	amec
DESIGN:	BAH		
DRAWN:	GWH		
DATE:	6/2006	McMICKEN DAM INSTRUMENTATION	FIGURE 1
SCALE:	N.T.S.		

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Instruction Manual

Model 1610

The Geokon/Ealey Tape Extensometer

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(Doc Rev A, 12/04)

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TABLE OF CONTENTS

Page

1. INTRODUCTION

1.1. Theory of Operation

The Model 1610 Tape Extensometer is designed to measure changes in the distance separating two fixed points. Most often the points are located on opposite sides of an underground opening, such as a tunnel, and the measurement is usually of closure of the tunnel walls, (see Figure 1), or roof/floor convergence caused by pressure in the surrounding ground. The tape extensometer is particularly useful for the measurement of deformation of the shotcrete tunnel linings used as part of the "New Austrian Tunneling Method" (NATM). It also finds use in the measurement of closure between the walls of open cuts, in cut and cover operations and between the walls of deep foundation excavation. Other applications include structures, buildings and unstable slopes. By using the same fixed points to locate a leveling staff or EDM target, it is possible to incorporate tape extensometer data into a more comprehensive monitoring survey.

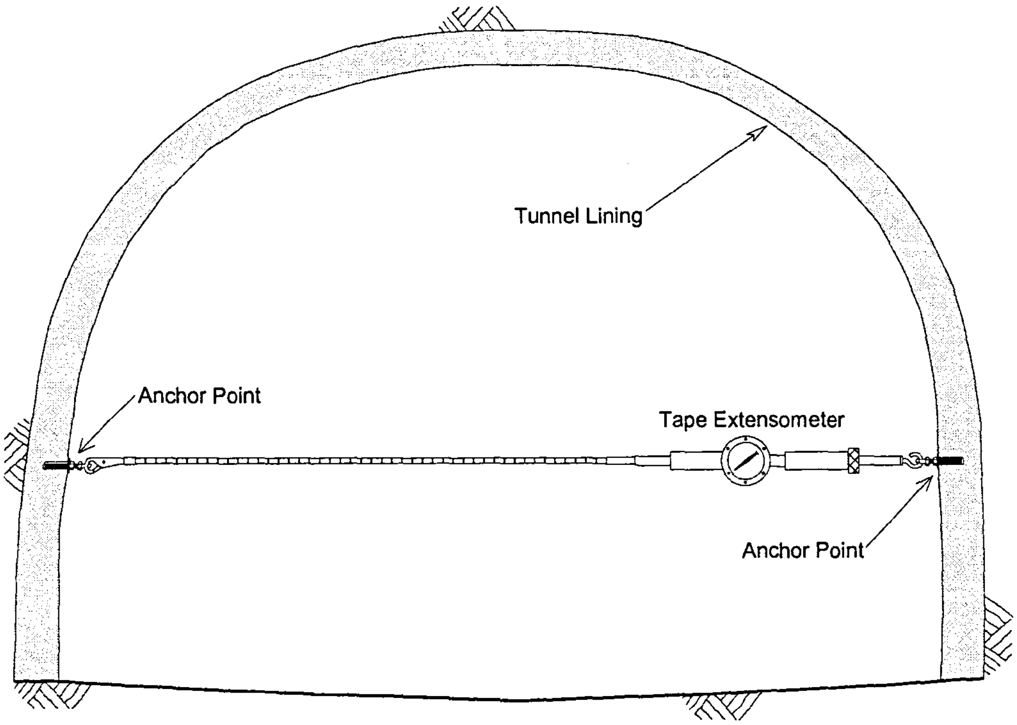

Figure 1 - Typical Installation

The Tape Extensometer has two purposes: to apply a consistent tension to a measuring tape, which has punched holes at regular intervals, and to provide an accurate reading of the distance from the punched hole being used to the eyebolt being measured.

1.2. Construction Details

Figure 2 shows details of the construction of the tape extensometer. The device consists essentially of a stainless steel measuring tape in which holes have been punched at regular intervals. This tape can be stretched between two points located on opposite sides of the underground opening. There is a hook on the end of the tape and another on the back end of the tape extensometer. A locating pin attached to sliding bars is designed to engage one of the punched holes in the tape. The correct hole is that which permits the tape to be tensioned to its correct tension as indicated by system of colored indicator lights. The tape extensometer can be shortened and the tape tensioned, by rotating a winding handle until a correct-tension indicator light is illuminated. At this moment the digital indicator will give the correct reading.

The precision of the instrument will depend to a large degree on the skill of the operator in achieving a consistent and repeatable tape tension. Techniques are described later, (see Section 3.2), which will maximize the precision and accuracy.

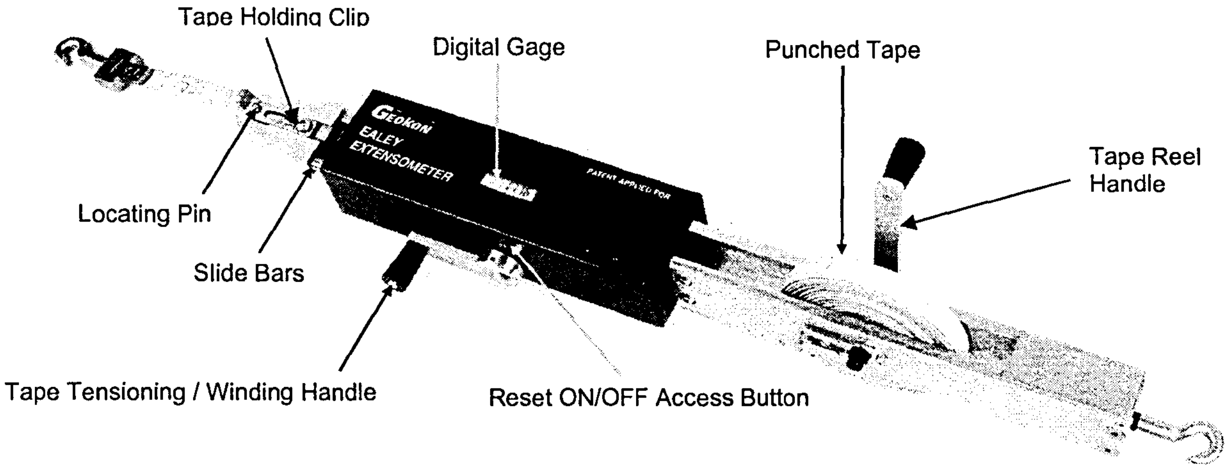

Figure 2 - Model 1610 Tape Extensometer

2. INSTALLATION

Anchor points are of three types as shown in Figure 3.

2.1. Groutable Anchors

An eyebolt is threaded into the end of a piece of ¾" (#6) rebar and the rebar is grouted inside a short (9" or 250 mm) borehole, or cast inside the shotcrete lining (NATM).

2.2. Expanding Wedge Anchors

An alternative to grouting is to use a rockbolt type expansion shell anchor inside a 1 3/8" diameter (35 mm) borehole. These anchors are recoverable.

2.3. Weldable Anchors

Occasionally anchors may be located on steel ground supports such as tunnel arches, steel tubbing or on soldier piles. The eyebolt is attached to a small steel plate, which is then welded to the structure. (Alternately an eyebolt can be screwed directly into a ¼-20 hole drilled and tapped in the steel member.)

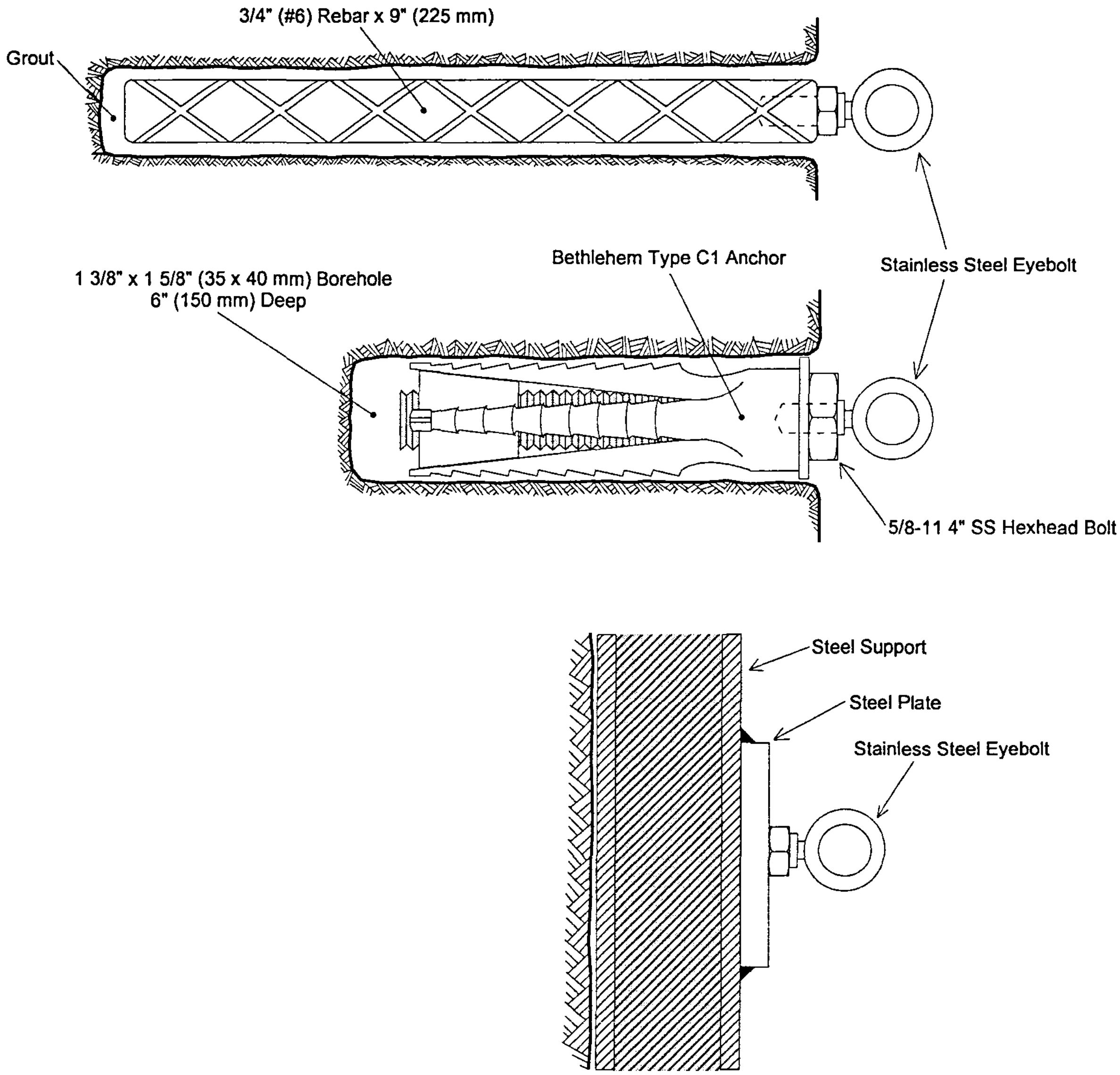

Figure 3 - Three Anchor Types

3. TAKING READINGS

3.1 Preliminary

Always make a careful note of the instrument and tape Serial Numbers when beginning a set of readings. Also note the temperature. Do not assume that the temperature underground will remain constant.

There is no on/off switch for the tension indicator lights - the tension device operates automatically. Ensure that the battery-holder contains a charged 9-volt battery before commencing and that the digital gage is on. If the gage is off, switch it on as described in Section 6.3.2.

Before commencing, make sure that the display reads 0.00mm, (0.00inches), when the winding handle is turned fully clockwise until it will turn no more - it will come to a natural stop, **do not force the winding handle**. If the reading on the digital gage does not show 0.00mm, or 0.000inches, refer to section 6.3.2 for further details on how to reset the zero.

Turn the winding handle anti-clockwise until the sliding bars are fully extended, the gage should read at least 55mm, (2.200 inches).

(See Section 5 for recommended zero stability checking procedures)

3.2 Tensioning the Tape

Correctly tensioning the tape requires a certain amount of skill. It is recommended that the operator practice the recommended technique until it can be performed rapidly and consistently. Refer to Section 5 for further details.

3.2.1 Hook the tape onto the first eyebolt and the instrument onto the second eyebolt.

3.2.2 Using the tape reel handle, reel in the tape so as to remove as much sag as possible then place the nearest punched hole over the locating pin and secure in place by sliding the slotted clip all the way over the tape and pin.

3.2.3 Turn the tape tensioning winding handle clock-wise until one or both of the indicator-lights comes on. Turn the winding handle back a small a mount until both lights go off.

3.2.4 Turn the winding handle clock-wise, in small increments, until only the green light is on when the instrument is at rest, untouched by the operator.

3.2.5 Place a finger under the tape, as shown in figure 4, and **gently** lift the tape so as to relieve a small amount of tension on the tape – the green light should go off. **Gently** removing the finger should cause the green light to come on again. If the green light stays off, turn the winding handle clock-wise a small amount until enough tension is being applied so that the green light goes on and off again with gentle placing and removing of the finger under the tape. The tape is now at the correct tension.

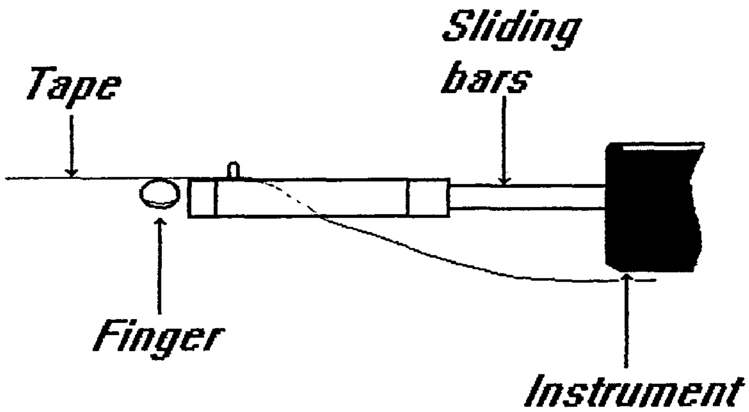

Figure 4. Tensioning the Tape.

3.2.6 If the red light comes on the tape is over-tensioned, so turn the winding handle anti-clockwise and return to step 3.2.3. Alternatively, it may be that the finger-pressure being applied to the tape is too great, or, being applied too roughly.

3.2.7 The red light is set to illuminate at between 0.2 to 0.3 mm after the green light. Over long distances (15 meters or more), tape flutter may cause the red light to come on too soon. If this is the case, return the instrument to the supplier for adjustment, specifying the conditions under which the instrument is required to operate.

3.3 Taking the Reading

Once satisfied that the correct tape tension has been applied, take the reading on the digital gage. It may be necessary to twist the instrument in order to read the gage and this may cause the red or the green light to come on. However, the reading on the digital gage will remain the same so long as the winding handle is not moved.

The travel of the digital gage is slightly larger than the pitch of the punched holes. As a result it may be possible to take readings on two of the punched holes. To avoid this it is recommended that the sliding bars always be fully extended when commencing each reading.

The total reading is the sum of the distance along the tape indicated by the punched hole used, plus the digital gage reading, plus any correction that is required to account for temperature variations, as described in section 4. (Note that the tape starts at the same dimension as the nominal length of the instrument from the centerline of the pin to the centerline of the hook. In the case of metric units this is 500mm and, for the English units, 20 inches.).

After the reading has been taken, turn the winding handle anti-clockwise, until the sliding bars are fully retracted, then remove the locating pin from the tape. The instrument is now ready for the next reading. For better accuracy it is recommended that all readings be repeated a number of times and the average taken.

4. TEMPERATURE CORRECTIONS.

The coefficient of thermal expansion, K, for the punched tapes is:

$$11.6 \times 10^{-6} \text{ meters/meter/°C}$$

or

$$6.45 \times 10^{-6} \text{ meters/meter/°F}$$

(Inches/inch can be substituted for meters/meter)

For a tape of length L and a temperature change ΔT, the apparent change of length of the tape ΔL due to ΔT is:

$$\Delta L = L\ K\ \Delta T$$

If the initial temperature is T_0 and a subsequent temperature is T_1 then let $\Delta T = (T_1 - T_0)$ and the apparent change in length is:

$$\Delta L = L\ K\ (T_1 - T_0)$$

For rising temperatures $T_1 > T_0$ the tape will expand, ΔL will be positive causing a subsequent reading R_1 at T_1 to be too small. Hence when $T_1 > T_0$ the correction to R_1 will be positive and when $T_1 < T_0$ the correction will be negative, or, correction to R_1 is:

$$L\ K\ (T_1 - T_0)$$

If we let $L = R_0$ expressed in the appropriate units then the required correction to R_1 is:

$$+ R_0\ K\ (T_1 - T_0)$$

So if the apparent change in distance ΔD as measured by the difference between an initial reading R_0 at a temperature T_0 and a subsequent reading R_1 at a temperature T_1 then:

$$\Delta D_{apparent} = R_1 - R_0$$

and the true displacement ΔD_{true} corrected for temperature will be:

$$\Delta D_{true} = R_1 - R_0 + R_0\ K\ (T_1 - T_0)$$

4.1. Metric Temperature Correction Example

A Metric type extensometer shows an initial reading (R_0) at 20°C (T_0) such that the tape pin falls in the hole located at 10.45 meters while the reading on the digital gage is 32.34mm or 0 03234 meters. The measurement is:

$$\begin{array}{r} 10.45 \\ + 0.03234 \\ \hline 10.48234 \end{array}$$

meters

A subsequent reading (R_1) taken at a temperature of 0°C (T_1) appears to be 10.49654 meters so the apparent displacement, $R_1 - R_0 = 0.01420$ meters or = + 14.20 mm.

The required correction for temperature is:

$$+ (10.48 \times 1000) \times 11.6 \times 10^{-6} \times (0 - 20)\ \text{mm}$$
$$= -2.43\ \text{mm}$$

So the true displacement is: $\Delta D_{true} = +14.20 - 2.43$

$$= +11.77\ \text{mm}$$

4.2. English Temperature Correction Example

An English type tape extensometer shows an initial reading (R_0) at a temperature of 30°F (T_0), such that the tape pin falls in a hole located at 34', 4" while the reading on the digital gage reads 1.378 inches.
The measurement is:

34'	4.00"
+	1.378"
34'	5.378"

A subsequent reading (R_1) taken at a temperature of 80°F (T_1) appears to be 34', 6.262" equal to an apparent displacement $\Delta D_{app} = R_1 - R_0 = +0.884$ inches.

The required correction for temperature is:

$$+ (34.45 \times 12) \times 6.45 \times 10^{-6} \times (80 - 30)\ \text{inches}$$
$$= +0.133\ \text{inches}$$

And the true displacement is: $\Delta D_{true} = +0.884 + 0.133$ inches

$$= +1.017\ \text{inches}$$

5. ZERO STABILITY CONTROL

Always set up two test-point eyebolts mounted on a stable structure whose dimensions do not change. This can be between two walls of a stable underground opening or between opposite sides of a steel framework kept in a stable temperature environment. Use these test points at regular time intervals, preferably at the start of each measurement survey, to ensure that the self-length of the tape extensometer does not change with time. It is important that zero readings be accurate so repeat the reading a number of times, (10 or more), until the accuracy of the recorded value is beyond doubt.

The zero stability control points will also be useful for practicing the measurement technique described in Section 3.2.

Note: It is important that the test point eyebolts be stable, that is, firmly fixed and immovable. Eyebolts attached to objects, which can move even slightly will make it impossible to perform the measurement technique as described in Section 3.2.

It is good practice to extend the monitoring survey to a point outside the area likely to be affected by movements. In this way there will be seen to be confirmation that the tape extensometer records no movement in those areas where no movement is expected. This will go a long way to improving confidence in the readings taken from the active area.

Any gradual or sudden change in the zero reading will indicate the need for servicing and recalibrating the instrument. (See Section 7).

6. MAINTENANCE

6.1. Care of the Tape

Care should be taken to keep the instrument clean. ***Avoid dragging the tape along the ground at all times!*** The tape should be treated with the same care as any precision surveying tape. The greatest danger is kinking the tape and extreme care should be taken to prevent traffic from damaging the tape while in use. When reeling in the tape pass it through a rag to remove dirt and moisture. Broken tapes can be replaced easily with new tapes. Simply remove the clip and screw holding the tape-winding handle.

6.2 Care of the Instrument

The instruments working life will be extended if care is taken to keep the instrument clean. Whenever the instrument has been exposed to dirt or moisture clean it with a soft cloth at the end of the day, paying particular attention to the sliding bars.

Store the instrument with the sliding bars retracted so that the gage reads between 3mm and 5mm.

6.3 Care of the Batteries

6.3.1 The 9 volt Battery.

The 9 volt battery powers the indicator lights and may be removed if the instrument is to be stored for any length of time. The 9 volt battery holder is located on the rear face of the casing.

6.3.2 The Digital Gage Battery

The digital gage is powered by an internal battery, which has a life of about one year in normal use. A small letter **B will appear in the display when the battery is low.** In order to preserve the life of the digital gage battery it should be switched off after use, unless the instrument is being used daily.

The digital gage may be switched on or off as follows: The on/off switch button is located next to the Tape Tensioning Handle. By keeping the button depressed for a few seconds the gage will be switched on or off. If the digital gage battery is switched off then on switching it back on the gage zero will require re-setting.

The digital gage should read 0.00mm, (0.000 inches), when the winding handle is turned fully clockwise. If this is not the case then gently depress the switch button twice. The display should now read zero. If the display does not read zero repeat the procedure making sure that the winding handle is fully stopped before pressing the button. Again, do not force the winding handle.

6.3.2.1 Changing the digital gage battery

Changing the digital gage battery requires a special tool and if not performed properly can result in damage to the gage and loss of calibration. Therefore it is recommended that the instrument be returned to the supplier if a new battery is required. A new battery is always installed when the instrument is returned for routine servicing. However, if the battery is changed in the field the following procedure should be observed.

Remove the printed Polycarbonate cover.

Remove the 3mm. socket head screw holding the circuit board to the gage supporting plate.

Remove the 5mm. socket head screw securing the gage slide to the moving block.

Remove the 4 No. 3mm socket head screws holding the gage supporting plate to the body and lift out the supporting plate with the gage attached.

Remove the battery cover from the rear of the gage by sliding it upwards and remove the battery using the special tool or a small screwdriver. Replace the battery with a new CR2032 battery making sure it is the correct way up. Use a cloth to keep the battery clean as finger marks can cause tracking across the surface resulting in early discharge.

While the gauge should automatically reset, if it fails to do so and displays "error" or peculiar numbers, reset by using the reset button on the rear of the gauge. The reset button can be operated with a small pointed object, such as the tip of a ballpoint pen. **The gauge will always reset to millimetres so remember to set instruments with English readouts (serial numbers with an A prefix) to read in inches.**

Replace the supporting plate in the instrument then replace and tighten the 4 screws holding the plate. Put the circuit board back in place and secure with the screw.

Replace and tighten the 5mm. screw and washer making certain that the slide is pushed up to the screw and does not jam against the rear of the body and that no wires are in danger of being crushed by the end of the gauge slide when the instrument is fully retracted. Replace the cover.

7. SERVICING

It is recommended that the instrument be returned to the supplier at least once per year, for service and calibration. The instrument may be returned for a calibration check and the issue of a new calibration certificate at any time.

8. SPECIFICATIONS

Model 1610 Tape Extensometer Specifications

Available Ranges[1]:	15m, 20m, 30m, (50 ft., 66ft, 100 ft).
Accuracy[2]:	±0.01mm, (±0.001in).
Repeatability[3]:	±0.1mm, (±0.004in).
Tension on the Tape	10 , kgf (22 lbs)
Overall Length	520mm. (20.5 inches).
Case Dimensions	500 × 350 × 125mm, (20 × 14 × 5in).
Weight (with case):	2 kg., (4.4 lbs).
Indicator Light Battery	pp3, 9volts
Digital Gage Battery	CR 2032 3 volts

Table A-1 Model 1610 Specifications

Notes:

[1] Other ranges available.

[2] Accuracy of the digital gage equal to the resolution (±1 graduation)

[3] Repeatability – this is the system accuracy to be expected under normal conditions and takes into account trained operator error, friction in the system, temperature variations and placement errors. The repeatability is affected by the environmental conditions under which the readings are taken and may be significantly worse than as shown.

McMicken Dam
Flood Control District of Maricopa County
Instrument Monitoring Data Collection Worksheet

TAPE EXTENSOMETERS

Date: ______________________________

Collected By: ______________________________

From	To	Cor. Prior Reading xx/xx/2006		READING No. 1			READING No. 2		
				Measured Distance		Temp	Measured Distance		Temp
		Feet	mm	Feet	mm	deg F	Feet	mm	deg F
TE1A	TE2B								
TE2B	TE3C								
TE3C	TE4D								
TE4D	TE5A								
TE5A	TE6B								
TE6B	TE7C								
TE7C	TE8D								
TE8D	TE9A								
TE9A	TE10B								
TE10B	TE11C								
TE11C	TE12D								
TE13A	TE14B								
TE14B	TE15C								
TE16D	TE17C								
TE17C	TE18B								
TE18B	TE19A								

From	To	Cor. Prior Reading xx/xx/2006		READING No. 1 Measured Distance		Temp	READING No. 2 Measured Distance		Temp
		Feet	mm	Feet	mm	deg F	Feet	mm	deg F
TE20A	TE21B								
TE20A	TE22C								
TE20A	TE24D								
TE21B	TE22C								
TE21B	TE23A								
TE21B	TE24D								
TE22C	TE23A								
TE22C	TE24D								
TE25C	TE23A								
TE24D	TE25C								
TE25C	TE26A								
TE26A	TE27B								
TE26A	TE30D								
TE26A	TE28C								
TE27B	TE28C								
TE27B	TE29A								
TE27B	TE30D								
TE28C	TE29A								
TE28C	TE30D								
TE29A	TE30D								
TE30D	TE31C								
TE31C	TE27B								
TE31C	TE29A								
TE31C	TE32D								
TE32D	TE33A								
TE33A	TE34B								
TE34B	TE35C								

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ATTACHMENT B

ROD EXTENSOMETER MEASUREMENT INSTRUCTIONS

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ROD EXTENSOMETER MEASUREMENT INSTRUCTIONS

Prior to initiation of measurement AMEC recommends that the person conducting the measurements is properly trained by someone experienced in the collection of rod extensometer measurements at the dam site. The precision of the instrument will depend to some degree on the skill of the operator in achieving a consistent and repeatable measurement.

The following instructions shall be read in their entirety before initiation of any measurements.

Equipment

The following equipment is required for rod extensometer measurement:

(1) FCDMC owned Starrett depth micrometer
(2) FCDMC owned Fluke 51 II Thermometer

Measurement Procedures

The following procedures should be followed to measure the rod extensometers:

(1) Measurements should be performed early in the day when there is not direct sunlight on the reference table or the exposed rods.
(2) Each rod extensometer reference sleeve on the reference table should be examined for obstructions or excess dust. Clean out if necessary.
(3) Prepare the depth micrometer by selecting and attaching the most appropriate micrometer extension rod (included in the micrometer storage case) that will allow measurement from the reference table apparatus to the end of the rods.
(4) Place the Fluke thermometer in the shade.
(5) Toggle thermometer *Power* “on” then “off” and then “on” again.
(6) Set thermometer to “Max Hold”
(7) Select the rod to be measured and carefully insert the depth micrometer measurement rod through the back side of the reference table apparatus, through the 5/32” adjustable alignment hole and into the rod sleeve. **DO NOT ALTER THE POSITION OF THE ADJUSTMENT PIECE.**
(8) Adjust the micrometer so that the wings of the micrometer sit flush against the back side of the measurement apparatus.
(9) Adjust the micrometer so that the micrometer measurement rod abuts the extensometer rod while the micrometer wings maintain full contact with the back of the measurement apparatus, mentally record the measurement.
(10) Back off the micrometer measurement and repeat step 8.
(11) Repeat steps 8 and 9 until the readings are consistently within a couple hundredths of an inch (about 3 times), remember the final reading.

(12) Attach the thermometer to the temperature leads and acquire the temperature.
(13) Record the rod extensometer micrometer reading on the standard data sheet.
(14) Record the temperature on the standard data sheet.
(15) Repeat steps 4 through 14 for the other rods taking a total of 2 readings per rod.

Data Analysis

(1) Enter data recorded on data collection sheets into the rod extensometer data analysis spreadsheet.
(2) The spreadsheet corrects each reading for temperature based on the following expression:

$$MF_c = [(MF_{in})K(T_o - 80)] + MF_{in}$$

MF_c = field measurement corrected (in)
MF_{in} = field measurement (in)
T_o = rod field temperature in degrees (°F)
K = coefficient of thermal expansion (in/in/°F) = 6.45×10^{-6}