Common Sense in Dam Anchoring

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Introduction

At a recent international conference, your correspondent gave what he thought was a clear statement of current U.S. practice in the use of prestressed rock anchors for stabilizing concrete dams. He presented this overview to what he thought was an audience wholly cognizant of rock anchor technology: after all there were no questions from the floor, and there were knowledgeable/bored looks all round.

However, during the ensuing coffee break, a certain (senior) dam engineer approached your correspondent and made the following statement, reported verbatim: "Yeah, I've used anchors for years, but tell me: how do **you** get the anchor to expand against the borehole wall and what does all the concrete you pour in really do anyway?"

Later, in the safety of the cocktail lounge, your correspondent had recovered his wits to the extent that he began to think that this rupture of communications was not necessarily and **entirely** his fault. Now, confidence is a fragile thing, and to guard against future assaults of similar nature, he thought that perhaps it would be useful to make an unequivocal statement on certain aspects of the business. In this way our (senior) dam engineer - and possibly other fellow experts - would be spared the horrible sight of your correspondent's face in apoplexy (again).

This brief collection of statements is the outcome. (The serious reader referred to the papers listed at the end.)

All You Wanted to Know About Rock Anchors and Were Afraid...

General

1. No one who installs rock anchors should be legitimately regarded as an "expert": the subject and its problems are not finite.
2. Conversely, everyone who installs anchors should be a "specialist": there is a great deal more to the business than hiring a driller and buying some post tensioning hardwear.
3. Similarly, there is often great potential for major economies if the experience of the contractor is tapped in a design-build option.
4. Recent jobs in the States have featured individual tendons over 200 feet long, weighing over 5 tons, and having an ultimate tensile capacity of 3100 kips. To paraphrase the new auto ad - "These are not your former old small bars".

Construction

1. The fastest, cheapest, and straightest method of drilling unreinforced concrete or competent rock is the use of the down the hole hammer.
2. Contrary to romantic speculation, the application of this compressed

air driven tool does not blow chunks off the face of dams, even when the hole is within 12 inches.

3. It is unreasonable to expect drill holes - especially if inclined - to be staighter than 1 in 100, and then only if the very best drilling practice is used.
4. Water tests on boreholes should be expressed in Lugeons, and for most information should be run by the Houlsby method. Such data will help unravel the mysteries created, for example, when holes readily accept water, but not cement grout.
5. Tendons should be handled with care and lowered by mechanical means into their respective boreholes. Helicopters look great but they are very expensive.
6. Except in cases involving extreme heat, or very long pumping distances - and assuming a colloidal mixer is used - there is no call to use admixtures for anchor grouts. Water cement ratios in the range of 0.4 - 0.45 (by weight) will guarantee acceptable fluid and set properties if properly mixed. Anything which aeriates, foams, or expands grouts should be sold to your closest competitor.

Testing and Performance

1. There is no ASTM Standard, although the PTI Recommendations are a terrific substitute.
2. On long, multistrand tendons, setting the alignment load on individual strands with a monostrand jack, prior to multistrand stressing is a very sound investment: This prevents the distinctive 'ping' sound which occurs at test load when some strands inadvertently reach G.U.T.S.
3. The data from the cyclic "Performance Tests", when correctly analyzed into permanent and elastic tendon components, can provide a wealth of knowledge about load transfer mechanisms. This is, sadly, little known and rarely conducted but it can soldve a lot of arguments between "experts" and "specialists".
4. Hydraulic jacks and load cells should be calibrated regularly. But, please, don't ask us to calibrate dial gauges as part of the Specification of Quality Control.
5. Tendons should never be loaded - even temporarily - over 80% G.U.T.S., and are far happier in less stressful conditions.
6. Assuming the anchor has been correctly designed, and that the concrete of the dam is properly cured, the only significant source of long term load loss is relaxation of the steel of the tendon. The magnitude is controllable and predicable. Relaxation is a fact of life.

Corrrosion Protection

1. For steel to corrode, it needs the presence of water and oxygen, and for these to be refreshed. This would seem to be more likely at the top of the tendon, than down the hole. Therefore, great attention to detail at this point is warranted.
2. Nevertheless, cement grout or grease alone cannot be reliably regarded as a corrosion protection barrier. There is thus a need for at least one layer of protection to the tendon which can be inspected **before** insertion of the tendon into the borehole.
3. The intensity of the level of corrosion protection is for the Owner or Consultant to decide, and for the Contractor to provide. You get what you pay for.

Final Remarks

These cryptic observations made by your concerned correspondent, frivolous as they may superficially seem, represent the distillation of concepts described at great length in the works listed below. Each observation is in response to frequently asked questions. Having read this, perhaps the "experts" may still remain omnisciently unconcerned, but your correspondent can confirm that at least one "specialist" has substantially reduced blood pressure as a consequence of this article.

Further reading for specialists:

1. British Standards Institution (1982). "Recommendations for Ground Anchorages". Drafted for Development DD81, BSI, London, 123pp.
2. British Standards Institution (1988). "Braft BS 8081: Ground Anchorges". Prepared for Issue in 1989 by

Technical Committee CSB/22. BSI, London.

3. Bruce, D.A. (1989). "An Overview of Current U.S. Practice in Dam Stabilization Using Prestressed Rock Anchors". 20th Ohio River Valley Soils Seminar, Louisville, KY, Oct. 27. 15 pp.
4. FIP (1982). "Recommendations for the Design and Construction of Prestressed Concrete Ground Anchors". FIP, Wexham Springs, Slough, England, 31 pp.
5. FIP (1986). "Corrosion and Corrosion Protection of Prestressed Ground Anchorages". Thomas Telford, Ltd., London, 28 pp.
6. Hanna, T.H. (1982). "Foundations in Tension-Ground Anchors". Trans. Tech. Publications. McGraw Hill Book Co., New York, 573 pp.
7. Hobst, L. and Zajic, J. (1983). "Anchoring in Rock and Soil". Elsevier Scientific Publishing Co. Amsterdam, Holland.
8. Littlejohn G.S. and Bruce, D.A. (*1977). "Rock Anchors: State-of-the-Art". Foundation Publications Ltd., Brentwood, Essex, England. 50 pp.
9. PTI (1986). "Recommendations for Prestressed Rock and Soil Anchors". Post Tensioning Manual, Fourth Edition, pp. 236-276. Published by PTI, 301 W. Osborn, Suite 3500, Phoenix, AZ 85013.

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