Instrumentation

John Dunnicliff

Introduction

This is the twenty-first episode of GIN. There are two articles following this column, both of which are self-explanatory, one on a serious technical issue, one to entertain you.

The first article, about liquid level settlement gages will, I hope, point some directions for the future. I've used these instruments several times in the past, usually with major frustrations, and a while ago vowed that I would never use them again. But having realized that the sources of error can be minimized by adopting the suggestions in the article and discussions, I am now willing to put them back in my tool box.

The second article has a boxed introduction at the beginning. Thank you, Lynn Pugh (Managing Editor of *Geotechnical News*) for accepting this non-technical article for publication. The older I get, the more I become certain that we need the maximum of fun in our lives.

The Puzzler

I included the following in GIN-17 (December 1998):

"A challenge, but no prize! Please let me know if you have any ideas or solutions.

- *An embankment on soft ground*
- *Concern for stability, with a possible failure surface primarily through one of the subsurface layers*
- *Open standpipe and vibrating wire piezometers in that layer. Enough of them to give confidence in the data, based on consistency*
- *After all piezometers reached equilibrium (settling down after installation, and after enough time for the open standpipe piezometers to overcome time lag), the vibrating wire readings of piezometric elevation were all much higher, by many feet, than the open standpipe readings.*

This is a real-world puzzler, not an academic exercise."

In GIN-18 I gave you a clue (but I messed things up, because when I repeated the puzzler, I got the higher/lower backwards, so I can't blame you if you were confused. Sorry about that!):

"Significant organic content in the

layer in question. But what mechanism is taking place, and how to be certain that reliable measurements of pore ***water*** *pressure are available for an effective stress stability analysis?*"

I've had about ten responses, some sound, some entertainingly wild. To all of you who responded — thank you for your contributions.

The mechanism: decomposition of organic material created gas. The diameter of the standpipes for the open standpipe piezometers were sufficiently large (this needs to be a minimum of about 10mm) so that the gas bled upward through the water in the standpipes, and the corresponding piezometric elevations represented the pore **water** pressure. The vibrating wire piezometers had standard coarse (low air entry) filters, allowing gas to pass through the filters, such that the piezometer readings represented the pressure of the gas in the piezometer cavity between the filter and the diaphragm. This pressure is always greater than the pore water pressure (red book, Section 2.1.11). The 'embankment' was a landfill, hence the decomposition and gas build-up was probably accelerated by heat. The difference between the piezometric elevations as measured by the two piezometer types was typically 20 feet head, i.e. **very** significant.

How to obtain reliable and timely measurements of pore **water** pressure? The open standpipe readings were of limited value because of time lag (slow response time). The solution: design a vibrating wire piezometer with a fine (high air entry) filter, which could be pushed into the layer. For such instruments to exclude gas and provide pore water pressure data, several criteria must be satisfied (red book Sections 9.11 and 9.14). The filter must be fine enough (ceramics with an air entry value of 2-bar were used); the potential path for gas through the filter must be as long as possible, to maximize the time for diffusion of gas through the filter; the filter and piezometer cavity must be completely saturated with de-aired water; and there must be direct hydraulic connection between the water in the filter and the water in the pores of the soil. This last requirement means that, for borehole installations, the piezometer cannot be surrounded by a sand pocket, but must be pushed into the soil so that filter and soil are in intimate contact. Hence robustness is added to the criteria.

A piezometer was developed that satisfied all the above criteria, and several were installed. And what happened? After these and nearby open standpipe piezometers reached equilibrium, they agreed with each other! To further demonstrate that the problem had been identified and solved, an 'old style' vibrating wire piezometer with a coarse filter was installed at the same time as the 'new' ones, and gave a much higher reading, just as before. Those were exciting days!

The next question must be, when do we need to use this new type of piezometer in soils at other projects? The organic content of the layer in question at the above project ranged from about 3 to 30%, with an average value of 12%. I've recently been involved with another embankment on soft ground (not a landfill this time, so no heat to aggravate the problem), where the organic content of layer in question averaged about 10%. Because we were (and are) totally unable to answer the question "at what organic content does generation of gas create a measurement problem?", we opted for the 'new' piezometers. Again they agreed with the open standpipes after reaching equilibrium.

For such instruments to exclude gas and provide pore water pressure data, several criteria must be satisfied...

One of the respondents to the puzzler, Ross Boulanger of University of California at Davis, pointed out to me that my reference to an effective stress stability analysis could be misleading. He commented:

"It is potentially quite unconservative to evaluate the stability of an embankment on soft soil using an effective stress analysis with pore water pressures based on current piezometric levels. The piezometric levels in the soft soil layer define the consolidation stresses, but not the stresses that would exist if the soil were to be sheared undrained. If a failure were to be triggered, soft silts or clays in layers of any appreciable thickness would likely fail in an undrained manner, and thus the pore pressures and effective stresses could change relatively quickly. Piezometer measurements of these changing pore pressures may not be obtained soon enough to respond to. Instead, the piezometric data should be used to define consolidation stresses and thereby estimate the available undrained shear strengths. A particularly good paper on this classic problem is Ladd's Terzaghi Lecture (ASCE JGE, April 1991), in which he recommends use of 'undrained strength analyses' over 'effective stress analyses' for this type of problem".

Videos

In GIN-8, June 1996 (page 36), I referred to a video by Ralph Peck, on the subject of controlling seepage and piping in dams, and quoted some of his wise advice on the role of instrumentation. I also told you how you could obtain the video. The source has now been changed, and four more videos have been added to the series. All relate to dams — mostly embankment dams, but Peck and Deere also talk about concrete dams/structures.

The titles and stars of the five are:

- "Seepage and Piping", Ralph Peck
- "Dam Foundations", Don Deere
- "Filters and Sinkholes" and "Rapid Drawdown Stability", John Lowe III
- "Ground Improvement and Dam Safety", Jim Mitchell
- "Behavior of Embankment Dams During Earthquakes", I.M. Idriss (in production; available fall of 2000)

The tapes are funded and produced by the Federal Interagency Committee on Dam Safety (ICODS), the Federal Emergency Management Agency (FEMA) and the US Bureau of Reclamation (USBR). Frank McLean of USBR has been the producer for the

series. Each title is on a set of two tapes. Each set currently costs US$ 20, which includes domestic US shipping and handling. International shipping and handling is extra. The videos may be obtained from The Association of State Dam Safety Officials (ASDSO), 450 Old East Vine, Lexington, KY 40507, USA. Tel. (606) 257-5140. Fax (606) 323-1958. Sarah Mayfield is the current contact person.

The following are comments from various reviewers:

"There's no cheaper way to get the world's experts to talk to your class, organization or you". "These programs are a must for any engineer or manager working in dams or dam safety, particularly if they are geotechnical engineers". "An economical and informative addition to a technical library". "A very valuable resource".

While on this subject, when I received a complementary copy of the first video in 1996, I wanted to give a copy to a colleague. I didn't feel comfortable about asking for another freebie, so took it to my local friendly video store in Natick, MA, for duplication. When I picked it up, Larry said, "I didn't know you were a plumber"!

Global Positioning System

A new capability has recently been developed for using global positioning system (GPS) technology for monitoring deformation in real-time. The product is called 'Hydra', and is described on page 64. It is claimed that deformations can be determined "to within a few millimeters". Anyone with a possible application may wish to follow this up.

An Anglo-American Contrast

My accountant in England had finished some preliminary work to establish my tax status here. He wrote, *"Having got more or less set up, as it were, with the Inland Revenue, I just wonder if you would prefer me to issue a bill now for the work to date. From our point of view, it is probably better. From your point of view it will mean not having a larger bill to pay later in the year"*. Isn't this wonderful? Can you imagine a US accountant writing those words?

Change of E-mail Address

IBM has sold its internet service business to AT&T, so a change of e-mail address has been forced on me. What a pain! New address: johndunnicliff@attglobal.com.

Closure

Please send contributions to this column, or an article for GIN, to me as an attachment in ms-word, or by fax or mail: Little Leat, Whisselwell, Bovey Tracey, Devon TQ13 9LA, England. Tel. +44-1626-836161, fax +44-1626-832919, or by e-mail to the above address.

Zivio! (Yugoslavia)

Fluctuating Readings of Vibrating Wire Settlement Cells

Wing Heung

Polk Parkway is a new toll highway in Lakeland, Florida, constructed by the Turnpike District of Florida Department of Transportation. During the construction of Section 3A of the parkway a phosphatic waste clay settling pond was encountered unexpectedly. The waste clay is a by-product of phosphate mining activity in the past. Its very soft consistency caused localized shear failure and affected the construction of an embankment and a Mechanically Stabilized Earth (MSE) wall in that area. A reinforcement system consisting of timber piles and geotextile reinforcements was designed to transfer the weight of the embankment and MSE wall to a more stable soil deposit beneath the waste clay (See Figure 1).

Background

A monitoring program consisting of one vertical inclinometer and four vibrating wire settlement cells (SC-1 through SC-4) was designed to evaluate the performance of the reinforcement system. Settlement cells were selected instead of conventional settlement plates due to their advantage of minimizing the disruption of construction activities. According to the manufacturer's literature, the settlement cell system is capable of detecting settlements as small as 2 mm (0.08 inch), which was believed to be better than the accuracy of conventional surveying method using settlement plates. The instruments were installed after the reinforcement system was constructed. Two of the settlement cells were installed beneath the MSE wall and the remaining two settlement cells were installed under an embankment area approximately 27 feet in front of the wall.

Settlement Cell Design

One of the components of the settlement cell system is a vibrating wire transducer. The transducer unit is buried at the location where settlement is to be measured. The transducer measures the hydraulic head at the bottom end of a

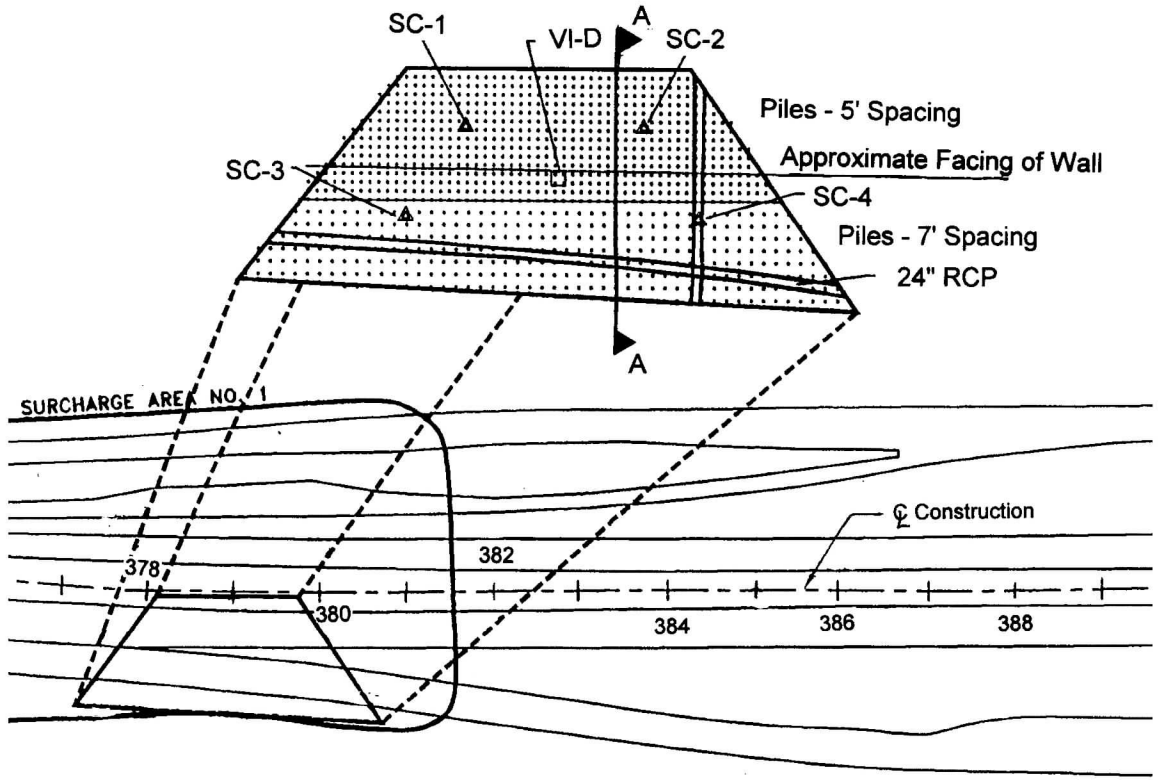
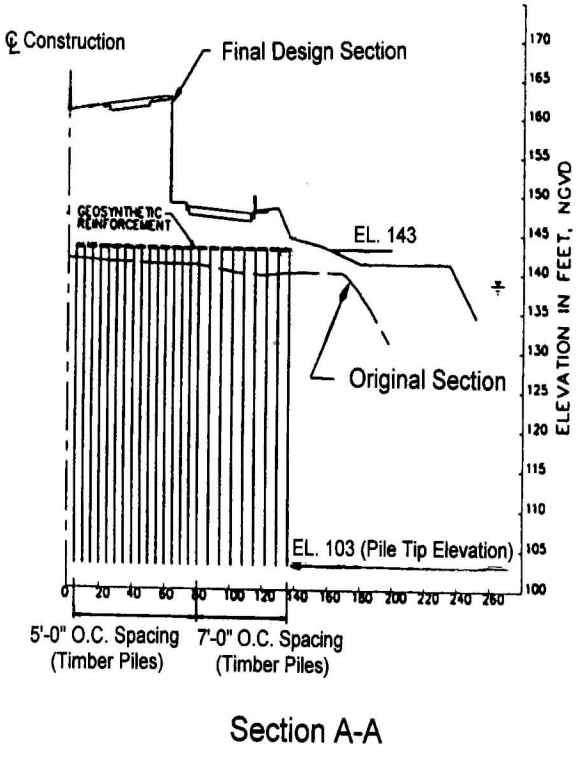


Figure 1. Reinforcement System and Settlement Cell Locations F



Section A-A

Figure 1. Reinforcement System and Settlement Cell Locations F

twin plastic tubing that connects to an open liquid-filled reservoir mounted on a post, erected outside the monitoring area (Figure 2). The tubings and the reservoir were filled with de-aired ethylene glycol-water mixture. Theoretically, as the surrounding soil and the transducer settle, an increase in the hydraulic head will be measured by the transducer and the settlement magnitude can be determined. This instrument is manufactured with a twin plastic tubing design to allow undesirable air bubbles to be removed from the liquid path. The twin tubing which connects at the transducer location allows the liquid path to be flushed and circulated by adding de-aired ethylene glycol-water mixture from the end of one tubing. Since the pressure measured by the transducer can be affected by atmospheric pressure at the open reservoir, a barometer reading was taken for each set of settlement cell readings obtained.

Prior to field installation, all settle-

ment cells were tested in the laboratory to verify the accuracy using the calibration coefficients provided by the manufacturer. The tests were performed by changing the liquid elevation of the open reservoir and compared with the corresponding changes in hydraulic head calculated from the instrumentation readings. The results indicated an average difference of approximately 3 percent, which was considered to be acceptable.

Fluctuation of Readings and Damage of Settlement Cells

After the installation of settlement cells, the embankment and MSE wall construction began. To compensate for any liquid loss due to evaporation, the liquid in each reservoir was refilled to its original level before readings were taken. The calculated settlement using the first few sets of readings indicated some negative settlement readings (heave) which fluctuated 1 to 1.5 inches between sequential readings (See Figure

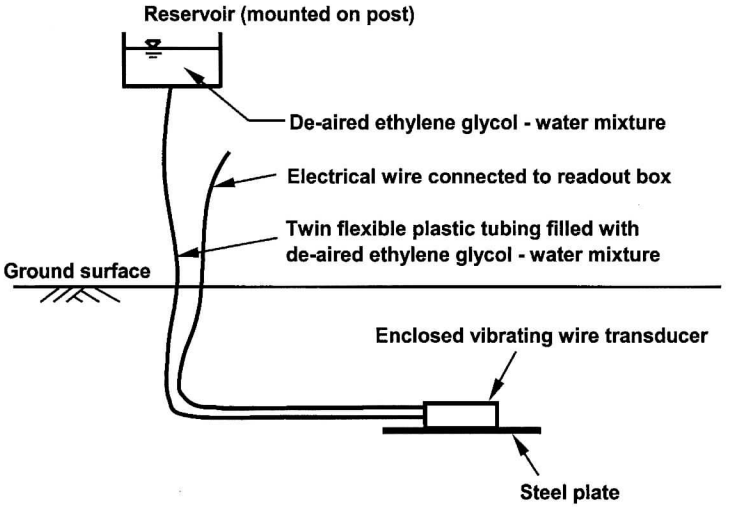


Figure 2. Schematic Components of Vibrating Wire Settlement Cell

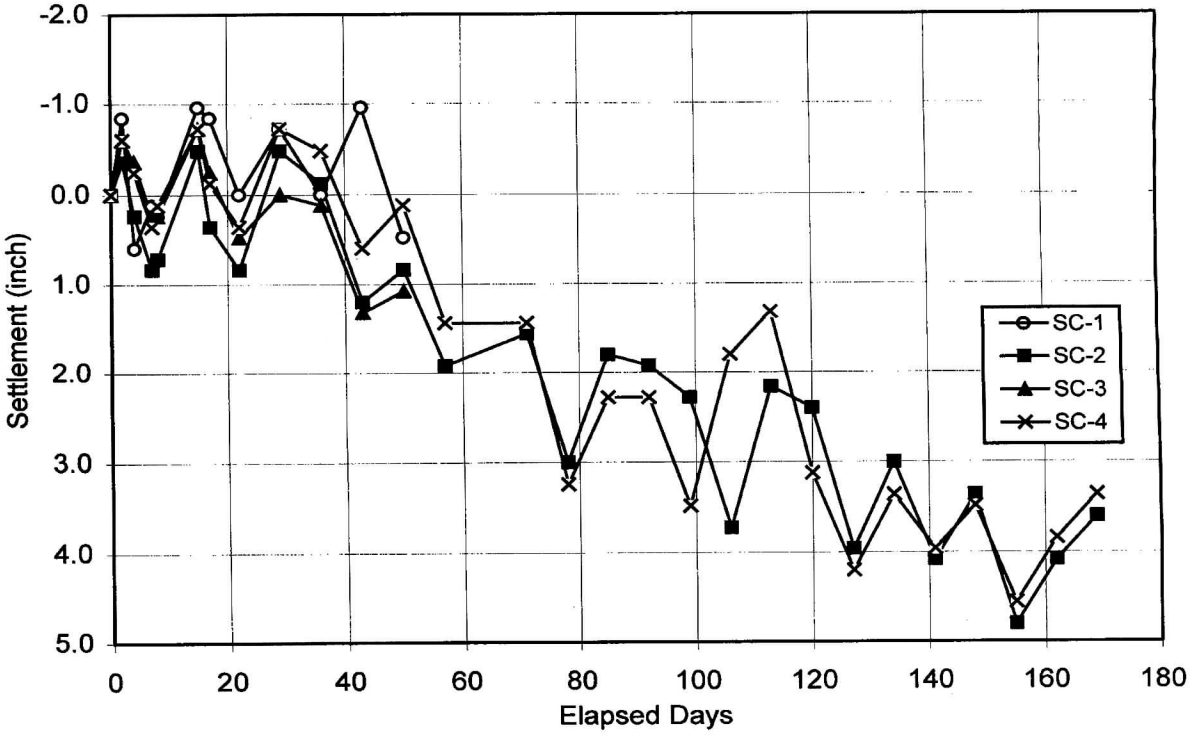


Figure 3. Settlement Cell Results

3). It was also noticed that most of these fluctuating readings were in unison with readings of other settlement cells. After observing the data for 17 days, it was decided that optical survey be added to the program to determine the settlement of the MSE wall while the source of problem with the settlement cells was being investigated. Shortly after that, the settlement cell, SC-1, located beneath the MSE wall and another cell, SC-3, beneath the embankment were permanently damaged by excavation activities in the field.

Investigation for Causes of Fluctuating Readings

Investigation was carried out in search of an explanation for the fluctuating readings. Three possible sources of error were considered and described below:

1. Possible Air Bubbles Inside Liquid Mixture

We investigated the possibility that air bubbles were accidentally introduced to the ethylene glycol-water mixture inside the tubing. It is known that erratic readings of this type of instrument can be caused by such a problem. Field tests were performed on the settlement cells. The open reservoirs were dismounted from the post and the reservoir elevation was adjusted in increments, up to 24 inches below the initial level. The purpose was to verify the system "stability", in that if air bubbles exist inside the tubing, it would cause an erratic change in the corresponding settlement measurement as the bubbles move to different locations inside the tubing. The test results did not depict a sudden erratic change in the calculated settlement. With a maximum test range of 24 inches, the settlement cells measured 25.9 inches of corresponding change, an error of about 7.9%. Although the percentage error increased from our laboratory tests performed on these units, the test results did not depict any erratic changes. Therefore, the test did not support the hypothesis that air bubbles caused the fluctuation of settlement readings. This is in agreement with the harmonic fluctuation of readings between settlement cells, suggesting a system problem.

2. Thermal Effect of Liquid Mixture

It was suggested that the effect of thermal expansion and contraction of the ethylene glycol-water mixture inside the reservoir and the exposed portion of plastic tubing might have changed the liquid density and affected the pressure at the transducer location. Since the temperature of the liquid in the reservoir was not measured during initial readings, its effect could not be traced back for earlier readings. The later readings have included the temperature measurement of the reservoir liquid using a thermometer. During the time period when temperature reading of the reservoir was included, the "uncorrected" fluctuation range of calculated settlements were approximately 1.3 and 1.1 inches at SC-2 and SC-4, respectively. After the correction of liquid specific gravity was included, the fluctuation range within the same time period remained essentially the same. It was therefore concluded that the thermal effect is not the main source of problem.

3. Accuracy of Barometer Reading

Investigation has also included the accuracy of barometer readings. The barometer used in the field had scales of 0.02 inch Hg increments. Field engineers recorded the barometric pressure to the nearest 0.01 inch Hg. At first glance, an accuracy of 0.01 inch Hg does not appear to be significant. However, due to the high specific gravity of mercury, 0.01 inch Hg is equivalent to approximately 0.13 inch head of ethylene glycol-water liquid. Therefore, it appears that barometer reading errors can cause a fluctuation of settlement readings by as much as 0.26 inch. Since, according to the manufacturer, the settlement cells are capable of detecting settlements as small as 0.08 inch, the maximum fluctuation of settlement readings can be expected to be as much as 0.42 inch. While this pointed to the importance of the accuracy of barometric pressure readings, it could not explain the maximum fluctuation of up to 2 inches observed.

Comparison with Survey Readings

Survey readings taken at the end of wall construction showed that the MSE wall panels settled approximately 0.1 to 0.6 inch. In comparison, for the same time period, the settlement cell readings indicated a fluctuation band averaging about 4 inches of settlement. Based on field observations, it is believed that the conventional survey method provides more realistic settlement data than the more sophisticated settlement cells in this project.

Conclusion

Our investigation could not identify the main source of problem with the vibrating wire settlement cell system. The settlement fluctuation which reached up to 2 inches was believed to be a result of a system problem because of the unison nature of settlement readings measured on the same day. If similar settlement cell systems are used in the future, it is suggested that actual accuracy of the readings provided by the settlement cells should be evaluated in conjunction with the accuracy of the barometer. It is also suggested that a backup plan involving other methods, such as surveying method in this project, be considered so that the project will not be affected.

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Discussion by John Dunnicliff

When I heard of Wing Heung's problems with the settlement cells, I encouraged him to prepare an article for GIN, so that we could have an open discussion and perhaps agree on how to solve the problems for the future. I have also had problems with these systems, as have several of my clients, and I discussed some of them in Section 12.10 of the red book.

I am concerned that readers may read Wing Heung's article and conclude that 'vibrating wire settlement cells (all, not just this particular version) have problems'. I hope that this is not the case, and want to try to send out a positive message.

Some years ago I arrived at the conclusion that the primary source of the problems was likely to be discontinuity of liquid in the liquid-filled tubes, and that the best way of dealing with this was to backpressure the liquid. If the liquid is discontinuous, application of sufficient backpressure will force the air into solution, hence solving the problem. By applying a series of measured increments of backpressure, the user can identify when the liquid becomes continuous because the response of the transducer will then be 1:1 with the backpressure. By subtracting the backpressure from the transducer reading, a correct measurement of hydraulic head will be made. Such an arrangement has an additional advantage, in that after 1:1 response occurs, several readings can be made with increasing backpressure, the readings plotted, and a 45 degree straight line drawn through the points, thereby increasing measurement accuracy. However, use of the backpressure feature comes with a disadvantage (there's no free lunch!), because the range of the transducer must be increased to accommodate the larger pressure, hence reducing transducer accuracy (accuracy of vibrating wire transducers is proportional to range).

Backpressuring is accepted by some manufacturers of these systems as an essential feature. Going outside the geotechnical instrumentation field, Gordon Green has told me that for many years Stanley Tools have been making a liquid level gage for measuring relative elevations during building construction ("COMPULEVEL", Stanley Tools, 600 Myrtle Street, New Britain, CT 06053, tel. 800-262-2161, fax 860-827-5926), in which the liquid is backpressured.

Hence I believe that these systems can be made to work, given the ability to backpressure the liquid, and given a good transducer, readout unit and barometric pressure measurement.

The method used to examine the possibility of air bubbles in the liquid may not have been adequate. Perhaps it would have been better to **increase** the head rather than decrease it, in an attempt to force any air bubbles into solution.

Recognizing the 'unison nature' of the fluctuations, might it be possible that the barometric pressure gage was out of calibration? Or is there a possibility of a problem with the readout unit?

In discussing these issues with the author, we agreed to ask the manufacturer for comments. A discussion by Slope Indicator Company follows, together with a closure by the author. Despite publishing this closure, I don't want to inhibit any reader from sending another discussion. Any further contributions will be welcome, and will be published in a later issue.

Discussion - Slope Indicator Company

Hai-Tien Yu and Rick Monroe

This discussion was initiated by John Dunnicliff, who forwarded Wing Heung's article to us. John asked us to provide a technical note regarding the use of settlement cells and the difficulties that Wing Heung encountered. The note below addresses the sources of error and possible configurations to minimize or eliminate them.

Possible sources of error in settlement cell readings

In his article, Wing Heung identifies three main sources of errors: air bubbles in the liquid, thermal effects on the liquid, and the accuracy of barometer readings. We agree and would like to share some of our findings and experience on dealing with these sources of error.

Air bubbles: The presence of air bubbles in the settlement cell or tubing will give rise to error in settlement cell readings because air is lighter than liquid. John's discussion suggests that air bubbles - or the discontinuity of liquid in the tubing - is likely to be the primary source of error in the system. He recommends back-pressuring the liquid to inhibit formation of bubbles in the tubing.

As a preventative measure, Slope Indicator ships settlement cells pre-filled with de-aired water. Special headers at

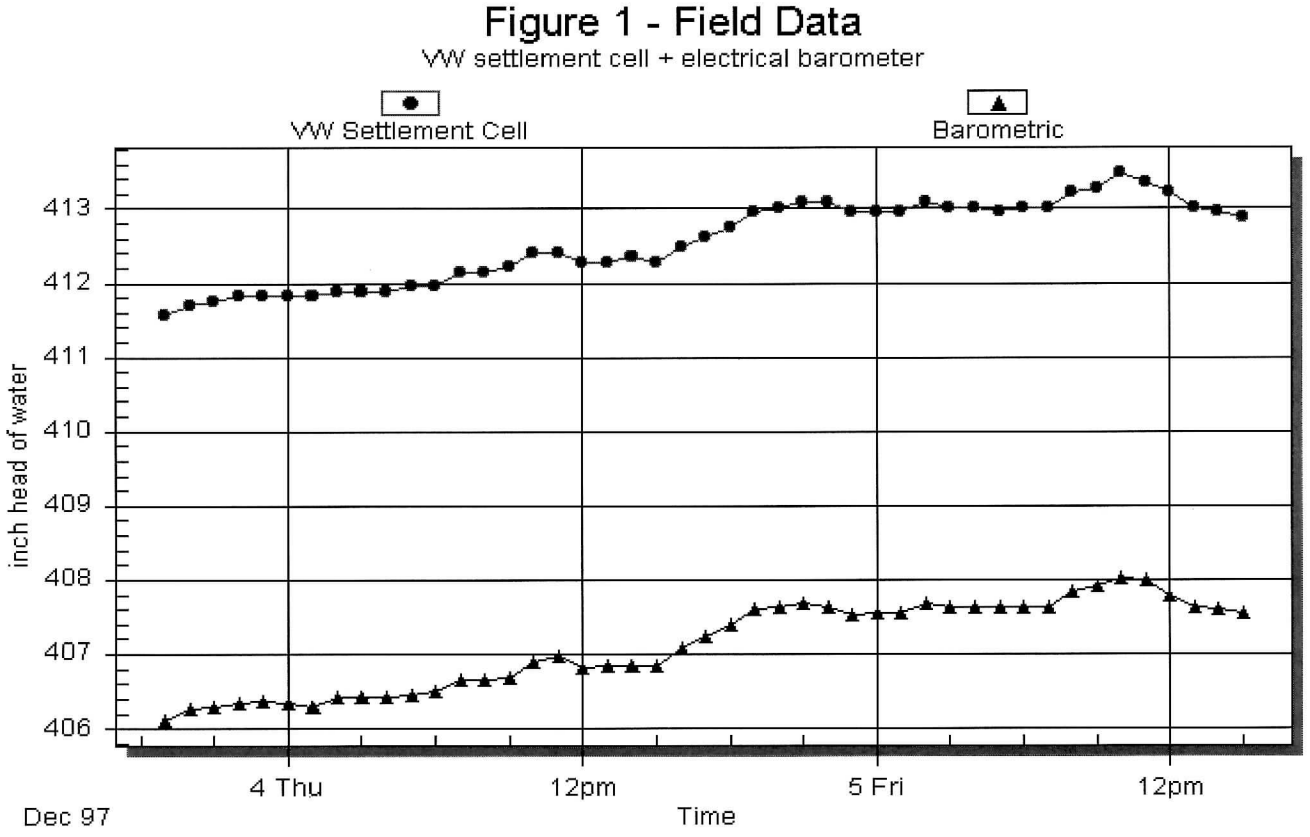


Figure 1. Field data

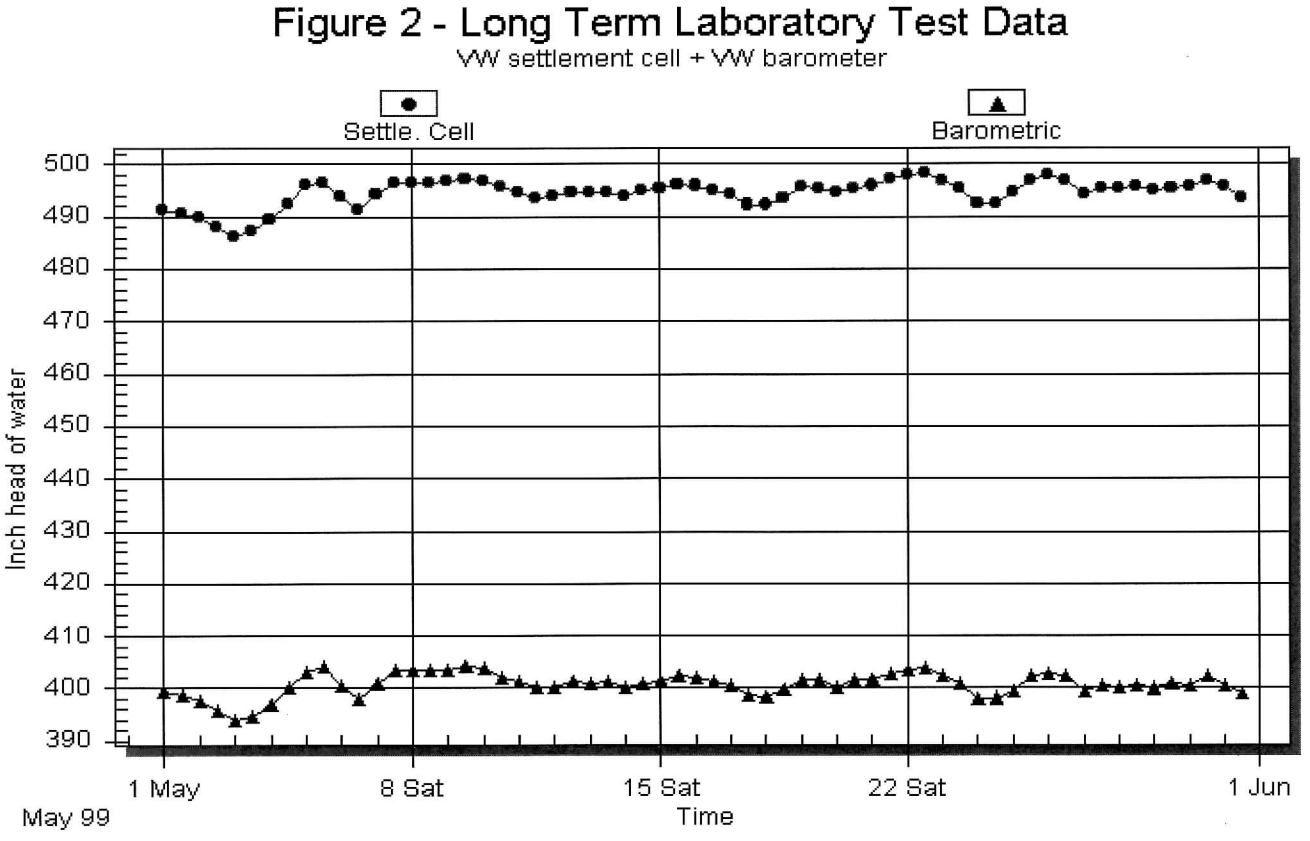


Figure 2. Long term laboratory test data

the reservoir end of the tubing are overfilled, so the liquid remains under pressure until the final step of installation. When tubing is connected to the reservoir during the final step of the installation, liquid actually squirts out of the tubing and no air is sucked in. In addition, Slope Indicator also supplies back-pressure systems (refer to Configuration 2 later in this discussion) in which the reservoir is sealed and pressurized.

Temperature: Temperature is typically not a significant factor, so long as the liquid does not freeze. Most of the tubing is underground, where temperature is relatively stable. Also, temperature of the liquid is significant only in non-horizontal tubing runs, since expanding and contracting of the liquid in the horizontal tubing due to temperature has no effect on the head of the liquid. As a result, it is prudent to minimize the length of tubing above ground, especially when it is a non-horizontal run.

Barometric pressure: If the reservoir is open to atmosphere, then the pressure of the atmosphere acts on the surface of the liquid, and the transducer sees the combined pressure of the column of liquid and the atmosphere.

Slope Indicator's first settlement cells used pneumatic transducers, which were vented to atmosphere. Such cells did not require barometric correction, since atmospheric pressure was present at both ends of the column of liquid.

The vibrating wire (VW) version of the settlement cell was developed for a customer who wanted to use a data logger to record large settlements in marine fills. The VW version of the cell employs a sealed transducer, so it is sensitive to barometric pressure. However, for that particular application, the magnitude of settlement was significantly greater than fluctuations in barometric pressure, so uncompensated readings provided satisfactory results.

Because VW sensors are easier to read than pneumatic sensors, and because the readings can be automated, the VW version of the settlement cell has quickly gained popularity. However, the convenience comes with a cost: if the cell is used to monitor small settlements, readings must be corrected for fluctuations in barometric pressure.

What is the magnitude of these fluctuations? Figure 1 shows 1.5 days of data from a settlement cell installed at a site in Isle of Wight, England. During this period, no settlement occurred, but the fluctuation in barometric readings is about 2 inches head of liquid. It also shows clearly that readings from the settlement cell closely follow the changes in barometric pressure recorded by an electrical barometer at the site. The difference between the settlement reading and the barometer reading is the head of liquid in the settlement cell (about 5.5 inches head of liquid).

Based on the scale of the barometer used in the field and the smallest settlement that the cell can detect, Wing Heung arrived at the figure of 0.42 inch head of liquid. He considered it as the "expected maximum fluctuation in settlement readings". In reality, this figure refers to the uncertainty of a single reading rather than the fluctuation of a series of readings. For example, in the above graph, the minimum barometric reading was 411.56 inches head of liquid, taken at 7 pm on 3-Dec-97 and the maximum barometric reading was 413.50 inches head of liquid, taken at 10 am on 5-Dec-97. Each reading had an uncertainty of 0.42 inch head of liquid but the fluctuation between the two readings was 2.06 inches head of liquid. Since there was no actual settlement, the 2.06 inches head of liquid fluctuation was caused entirely by change in local weather conditions.

Figure 2 shows a month of data from an on-going long term test we are conducting in our laboratory. Barometric pressure fluctuations of up to 13 inches head of liquid were recorded by a VW pressure transducer and no settlement actually occurred. Again, the difference between the settlement reading and the barometer reading is the head of liquid in the settlement cell (about 98 inches head of liquid).

Suggested System Configurations for Small Settlements

If the settlement cell is used to monitor small settlements (i.e. a few inches) , it is necessary to select a system that is free from the sources of error discussed above. John has made clear recommendations on how to address the air bubble issue so we shall deal with the correction for changes in barometric pressure below.

How should correction for changes in barometric pressure be done? Based on our experience and the graphs above, it is not sufficient to obtain barometer readings from the TV weather report or from the barometer on the office wall. Barometer readings must be obtained on site. In addition, the barometer reading must be obtained at the same time as the settlement reading. For the best results, we suggest using one of the following configurations.

Configuration 1: The reservoir opens to atmosphere and barometric pressure is measured separately, using a recording barometer or a VW pressure transducer (e.g. a VW piezometer). Settlement readings are corrected by subtracting the barometer readings from the settlement readings. Note that the barometer reading must be recorded near the location of the reservoir at the same time as the settlement reading. Liquid can evaporate from the reservoir, so it must be serviced from time to time.

Configuration 2: The reservoir is sealed and pressurized to isolate the cell from barometric pressure. This is the back-pressured system discussed earlier. A reference transducer monitors the pressure in the reservoir. Settlement readings and reference readings are taken at the same time, and the settlement readings are corrected by subtracting reference readings from settlement readings. This configuration is likely to provide the highest accuracy of any settlement cell system. It has the added advantage of preventing air bubble related problems. The pressurized reservoir can accommodate up to six settlement cells and prevents evaporation of the liquid, so that it normally does not have to be serviced. A customer in Canada reports that it gives good results. We are encouraging him to share his success with us in a future GIN article.

Configuration 3: The reservoir is sealed, but not pressurized. No reference transducer is used and no correc-

tions are applied. Since the column of liquid is isolated from the atmosphere by a sealed and rigid reservoir, it should not be affected by changes in barometric pressure. The sealed reservoir does not need servicing normally, since evaporation is minimized. For greatest accuracy, some care must be taken in the placement of the reservoir, so that it is not heated by the sun. Slope Indicator is testing such a system now.

Dr. Hai-Tien Yu and Rick Monroe, Slope Indicator Company, 3450 Monte Villa Parkway, PO Box 3015, Bothell, Washington 98041-3015 Tel: (425)806-2200 Fax: (425)806-2250 e-mail: solutions@slope.com, www.slopeindicator.com

Closure by the Author

I agree with John Dunnicliff's comment that my article certainly is not suggesting that all vibrating wire settlement cell systems will not perform properly. The purpose is to share with other readers about our experience and attempts made to investigate the fluctuating reading problem.

John Dunnicliff suggests to increase the liquid head during the tests for possible air bubble intrusion. Before the tests, the reservoirs were mounted near the top of posts, about 5 to 6 feet above the surrounding ground. We dismounted the reservoir from the post and performed the tests close to the ground level for convenience. I suppose, by increasing the head we would have a better chance to compress the air bubbles (if any) so that there would be a reduced reading error, but we did not realize this at that time.

Both John and Hai-Tien Yu questioned about the accuracy of the barometric pressure readings. The barometric readings were obtained in the field immediately prior to the settlement cell readings. Hai-Tien Yu was correct in pointing out that the accuracy of the barometric pressure may also be affected by the barometer calibration. These barometer readings were measured about two years ago and it is impossible to verify at this time. However, I agree that frequent calibration of the barometer would be warranted for this type of settlement cell.

A Day in the Life of a United Nations Lecturer in India

Elmo DiBiagio

The following 'letter' was written by Elmo DiBiagio to his colleagues at NGI (Norwegian Geotechnical Institute) in 1981. He showed it to me about a year later, and I read it with delight. It was particularly appealing to me because I had just come back from India, on a similar assignment for UN, but in Delhi rather that Poona. And, wow, did it capture the flavor of the experience?! The 'letter' reappeared in a volume entitled "Tribute to Elmo", to which many of us contributed in honor of Elmo's retirement as 'Mr. Instrumentation' from NGI in October 1998. Although formally retired, Elmo is still affiliated with NGI. Elmo questioned why I thought that this was appropriate for GIN. Clearly it is only marginally 'geotechnical', there's not much about 'instrumentation' (even though instrumentation is Elmo's 'thing'), and it isn't really 'news'. But it's fun, there are some pungent behavioral and philosophical messages, and if the Managing Editor of Geotechnical News will provide space for the 'letter', I believe you will enjoy it. One small item needs explanation to a North American audience, and ***small*** *is the right word. "Le Car" was a tiny French automobile, with lots of personality, and was hard to drive slowly. Elmo's "Le Car" was in fact a much larger vehicle, but the French flavor adds to the fun.*

John Dunnicliff

12 November 1981, 06:45 Hours

The telephone rings loudly! A pleasing voice says, "Good morning — have a good day". I reply, "Thank you". I get up late, by your standards and mine. A simple breakfast of pineapple juice and two pieces of dry toast. I gather up my notes and references and put them in the impressive black flight bag — with a chrome plated handle from Aeroimport A/S. I look like a pilot. Then I go down to the lobby and wait to be picked up. The sun is shining brightly — it always is!

07:24

I hear a familiar sound in the distance. The sound gets louder and louder — it is "Le Car".

At 07:30 exactly

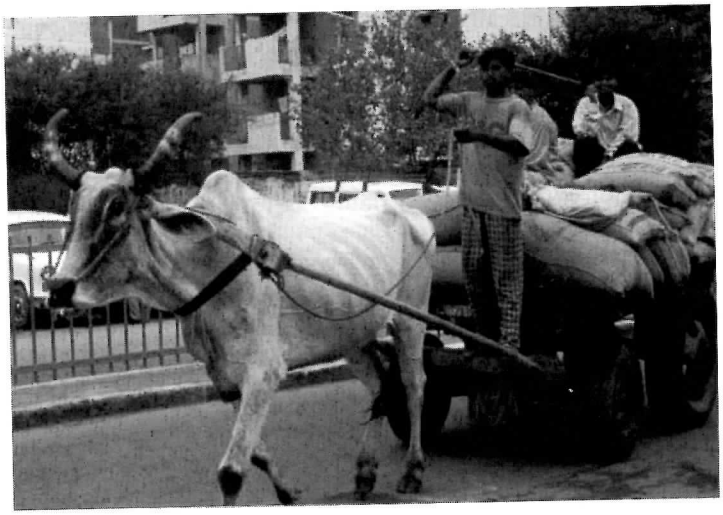
Le Car comes to a screaming halt in front of the hotel. It is driven by a local who picks me up every morning. Le Car is a station wagon. It is large and it has a big blue UN seal on both sides. A crowd of spectator's gathers around Le Car - they always do. Everyone wants to open and close doors for me. For a few moments chaos rules. It is the same every day. In one way Le Car is very special. It has two of the loudest horns I have ever heard. There is one loud horn to alarm people and animals, and there is one exceptionally loud horn to terrify people and animals, and UN lecturers in particular. These horns "blast" every 3 or 4 second on the average — first one, then the other — over and over again, without end. Fortunately there is an interlock that prevents the driver from blowing both horns at the same time.

07:31

My fancy black stress bag gets stowed away [in Norwegian, the slang expression for a briefcase is 'stress koffert', literally a stress bag, and it is symbolic of the stressed business people or young aspiring professionals who carry them]. Doors open and close, there is some confusion but after some moments all the doors are closed again — generally with me on the inside — but not always.

07:32

The last door slams shut — the motor roars and then it starts! What starts? The Motor Grand Prix of all times! The 37-minute, 20-km, long trip from the hotel to the Central Water and Power Research Station. As we race away the two horns signal to all, both near and far, that the event has started. We roar off — first through the city on narrow streets that are obstructed with every possible thing you can imagine. At accelerating speeds we wind in and out of cars and trucks and people and things. The first time it was terrifying, but now I am getting used to it. I wonder how I will drive when I get back to Oslo. After some minutes we leave the city and drive along a small country lane. The never ending blasts from the horn clear the road for miles ahead — sometimes but not always! Evidently there are many deaf people who can not hear the horns because they don't get out of the way. As a matter of fact, I have concluded that there are also an usually large number of chickens and dogs and cats, ox carts, push carts, wagons and trucks, cows and buffalo and horses and goats, men and mice, or women and children — who must all be deaf because in spite of the horns and all the decibels, these things and animals and people are always right in front of Le Car. They are also immovable. The driver says it is a result of the democratic process — people are allowed to do as they please, he adds, even squat in the middle of the road. The driver is also a democrat, I have concluded, because he drives wherever he pleases and at any speed he wishes. I believe he should drive on the left side of the road — but I am not sure yet. I need more data in order to make a reliable statistical evaluation. By the way, the driver is a good driver. So far we have not hit anybody or anything.



Street scene, India *(Photo: John Adams)*

As we speed along, in the city or in to the country the view from Le Car is not always pleasant. There are of course many nice things to look at and the landscape is beautiful. But it is hard to focus one's eyes on the nice things. There are far too many things that distract from the real beauty and charm that does exist here. I won't even attempt to describe what one sees, and even if I did you probably wouldn't believe me. Poona is considered to be one of the nicest living areas in India. But of a population of about one million, 330,000 inhabitants live in shacks and huts, in crates and cardboard boxes or nowhere at all. Many of the people simply exist on the streets — streetwalkers of another kind. The population of India is of the order of 760,000,000 - 185 times the population of Norway. After being here only about ten days I have the impression that I have seen each and every one of them. It's difficult to explain how it feels to be surrounded by so many people all the time. Le Car races on through an unending stream of people and things and shacks - it is hard to concentrate on other things.

08:10

Le Car has finished the daily race as it pulls into the Research Station, which is located in a remote wooded and green area south of the city. I am driven to the Coastal Research Center where I have my office on the second floor. My office is about 25 m^2. It has a desk, conference table, chalk board and a private WC. The view form the one small window looks

across a flat green valley to a mountain range in the distance. A nice view. I look out of the window every chance I get. But I have a lot to do — I end up in that situation wherever I am it seems.

08:12

A handyman brings in a cup of hot sweet tea. I get the same cup every day. He brews the tea on a "Primus" which is located on the stair landing between the second and third floors. The tea is extremely good and I drink it with reverence.

08:15

The first task is to get my slides in the right order for the next lecture. As usual I forget to bring one or two good ones, but I have enough to get through the lecture - so Im saved, for today anyway.

08:30 - 09:45

Members of the staff come and go. There are discussions related to the last lecture, some planning for the remainder of the day. I give my reference notes to a man who makes the reproduction. The UN representative comes in and says I received too much per diem for the week. He wants part of it back - no problem. There is no telephone in my office — the quiet is beautiful. I need more paper and ask someone to get it. I get 3 sheets. I ask for more, I get 10 sheets. I sent a telex to Camilla, my secretary in Oslo, and asked her to send me 2 pads of NGI paper. In the meantime I will write very small.

09:45

I try to discourage discussion with others so that I can review my notes for the next lecture. I feel unprepared - I always do. I generally get a few minutes to look through my notes, that's all. But so far it has gone well. I have 20 lectures to give all together; each one is two hours long. From now on, until the end of my stay, I have one such lecture each day, including Saturday. Yes, its a 6-day week here. I am giving 3 types of lectures. The first 7 were general background lectures about what we measure, how and why. These will be followed by 5 classical type case history examples, and the final 8 lectures will be related entirely to offshore projects.

10:00 - 12:00

I lecture on measurement of load and strain in structural members. It was OK. The audience has a varied background so one can not get involved in a lot of detail. Interest is high, but some people fall asleep. I can understand their problem so it doesn't bother me. There is a reasonable amount of discussion; however, I had anticipated more. It turns out the Research Station has very little experience related to full-scale instrumentation. I guess that is why I was asked to come in the first place.

12:15

I put the slides I used back in their proper place, file my notes away and start getting my papers, notes and thinking arranged for the next day's lecture. You know it really takes a lot of effort to prepare a two hours lecture. A day is not very long.

12:45

I go outside to get some sun and fresh air. Walk around the various pathways. The sun is very warn. Temperature in the shade about 26°C - very comfortable. There has not been any rain and I am told that there will not be any rain during my visit - only clear sky and sunshine. Must be nice to be a weather forecaster here! The grounds are beautiful, lots of flowers, green grass, banana plants, palm trees, coconut trees and many plants and bushes I have never seen before.

12:59

I hear the sound again! Le Car is on its way. I rush to the front of the building and am picked up at precisely 13:00 hours for lunch. We race off again - both horns blowing even though there is nobody or nothing around. We have to go about 2 km to a special dining facility for visitors. We accelerate all the way, and when we get there we are almost at the speed of sound. I brace myself as we come out of our orbit on earth. We stop in front of a little stone building set back from a lovely garden full of flowers and plants. I am allowed to walk the last 15 meters. There are two rooms, a kitchen and a dining room. There are 6 or 8 people in the kitchen, and an old man who serves the food. The dining room is about 50 m^2. The table is 5 m long and 2 m wide. I sit at one end. I am, have been, and will be the only visitor this month — so — I eat alone — all by myself. Can you imagine that? Sometimes I feel like a king, other times I feel like an outcast! It is a vegetarian meal - it always is. There are usually about 5 different courses, plus rice and soup. I do not recognize most of what I am served, but I eat what I am given and don't ask too many questions about what I am eating. That's the best way. The food is really good indeed - somewhat hot and spicy — but I don't mind. The driver waits in the car while I eat. After about 30 minutes I get up and walk the 15 meters back to the car.

13:35

Back at my office. The handyman brings another cup of tea. I work on the next lecture.

14:00

A staff member arrives to accompany me on a tour to one of the divisions of the Station that I have not visited yet. Today we visit the hydraulic model of Bombay harbor. They demonstrate several tidal cycles and point out the types of problems they have solved. It is impressive. The model covers an area of about 2000 m^2.

15:00

Back at my office. I note down the pros and cons of what I have seen. I must write a report to the UN before I leave. A group of people from the geotechnical division and harbor division come in and want to discuss instrumentation of a breakwater on soft clay. It is a difficult project and our discussions are difficult. In a way it is like starting all over at "zero" again. The discussions end at 16:00 because the workday has ended for the staff, but not for me. I work on my next lecture. The UN says I must work until 17:00.

16:30

I take a folding chair from the lecture hall and go outside. I set up my office outdoors. I want to sit in the sun and fresh air. The locals shake their heads and wonder. I read sometimes, or discuss various things with the staff members who drop in for a visit to my open-air office. Today they killed a rather

large snake just a few feet from where I usually set my chair. I believe they think it is too dangerous to do what I do. At 16:55 I go back inside and pack my stress bag.

17:00
Le Car's horns blast away in the distance. I run down the stairs to the entrance and am picked up again. Now it starts again the dreaded 20 km race back to the hotel. The trip is the same regardless of the time of day or in what direction one goes.

17:40
Back at the hotel. Off with shoes and shirt, flop down on the bed and think back over the days events - but not for very long. I fall asleep.

18:30
Wake up, wash, and start work on the notes for the next lecture.

19:45
Out for dinner. Chicken tandor. Very spicy but good. Rice to go with it and a bowl of sweet corn soup first. A pot of tea to drink. Costs about US$5. A half-hour walk through the city then back to the hotel.

21:00
Read the newspaper. The Times of India. Read that there was uranium-236 on the Russian sub that ran aground in Sweden. Work a bit more on the next lecture.

22:30
Off to bed but lie awake for a long time thinking about what I have seen today. In between, I think about the next lecture but somehow measurement of deformation doesn't seam so very important any longer. I think about my room at the hotel. If an Indian worker, who received the minimum wage, had to pay for my room he would have to work 56 days in a row just to pay the bill for one day. And if the same man had to finance my entire 4-weeks long stay at the hotel he would have to work about 4 years and 8 months without any days off - not even Easter Sunday! And that would not include my meals either. Its hard not to think about these things. Its hard to see how what I'm doing fits in - if at all. But perhaps the only solution to the problems here is through advanced technology. I don't believe the politicians can solve them, nor can the arm chair philosophers or social workers. What they need are high-speed brick making machines and things like that. By now, I am partly convinced that my next day's lecture has a purpose. I think of all the underfed people I've seen today. I think about my weight problem and about my per diem. If I wanted to, I could buy 2880 bananas with one per-diem allowance. The working man mentioned above could buy only 40, that's a big difference no matter how you look at it. To free my mind of all these problems I think about our cabin up in the mountains in Norway and about the new fireplace that I built just before leaving for India. It is a diversion but only a temporary one. I think about NGI, about working conditions there and the simple problems we have. I think of so many square meters of glass area in the lab, I think of the company doctor measuring the height of my desk, about the minimum specified distance between our desks and a window. I think of how time consuming and difficult it is to agree on trivial things like where to put a new telex machine. I think of §51 or whatever it is and all the laws and paragraphs that are needed to regulate our working conditions and protect us. As all these thoughts flash through my mind, all I can do is laugh a little to myself - it is so crazy. A pendulum can swing too far in two directions - much too far in one direction here in India and much too far, perhaps, in the other direction in the West - including Norway.

I think a lot about these things here. The night is very long sometimes and I do not sleep well. Sometimes, though, there are bugs in my bed and this is probably the main reason why I have some sleepless nights. I am so glad my wife is not here because she appreciates bugs in her bed even less than I do.

The Next Day 06:45
The telephone rings loudly. A pleasing voice says, "Good morning, have a nice day".

I reply; "Thank you, Ill try".

If we do not try, there is no possible way we can achieve what we want to do, or accomplish what is expected of us by others.

Best of greetings to all, and have a good day !
Elmo
Poona
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