# A modified approach for field logging in geotechnical & geo-environmental investigations

Ishtiaque Anwar
*Ground Instrumentation & Engineering Pte Ltd, Singapore*

S. Kumar
*Agaze International Pte Ltd, Singapore*

ABSTRACT: Based on the experiences garnered in geotechnical investigation works, we have devised a Systematized Field Logging process or SFL for an effective field data logging with apposite field information. At present, there is no standard field data-recording format. Our proposed new approach, SFL ensures our tweaked standard field data set - that is captured real-time - accurately validates and minimizes errors at point of entry. This process can be implemented through specially designed intuitive programs with user evaluation. This is a field-based solution, which does not compromise data quality. It promotes paperless real time logging, which also makes it environment friendly. For data security our process is ideal as almost no manipulation can be done. Better field logs can be generated within minimum time and can be delivered instantly. Allocation of professionally qualified manpower for on-site work can be reduced and streamlined.

## 1 INTRODUCTION

### 1.1 *General*

Soil survey explorations are made along any given area for the purpose of defining subsurface materials (Hvoslev, 1949). This information is used in the design of the requisite section - be it building, road, pavement etc. - as well as in defining the limits of unsuitable materials and any remedial measures to be taken prior to commencement of actual construction. Minimum criteria for soil surveys exist though they vary substantially, depending on location and the anticipated subsurface materials (Bowles, 1996).

There are methodologies for conducting specific In-situ Testing but no proper formats for data recording. There are many contractors in Singapore offering field logging services. Due to a lack of any proper formats, the drilling operators write what they observe and what they perceive to be correct, where in most cases it may not be, leading to vicarious situations.

As there are no hardbound rules for site data recording, most of the time there are submission of adumbrated field logs. This usually forces professionals to render manipulated data (unintentionally), sometimes leading to unexpected results.

### 1.2 *Providing a Solution*

An ideal situation to counter inaccuracies would be to introduce a new format of data recording that is easier to use and have the real-time involvement of all the concerned professionals. A new system called "*Systematized Field Logging*" (SFL) has been conceptualized. The process ensures that data is captured real-time, accurately validates and minimizes errors at point of entry.

### 1.3 *Related Works*

Our approach for field logging is inspired by the difficulties of site investigations we faced in our daily work and we decided to develop the process. We divide related work into two sections. First, we briefly summarize recent approaches for enhancing the present logging systems in general that are related to our process. Finally, we discuss the reasons we need to pay our full attention to the proposed process. *'Dataforensics'* developed a system for simple logging such as test pits and logging for contamination study using PDA that still fell short on field performance. (Dataforensics, 2012) The major disadvantage being that the small interface and intricate user interface limits the performance.

Our process uses screens that suit the user with evaluated graphical user interface. A few commercial tablet based data capture applications tweaked from the mining industry and rudimentarily focusing on geology/ geochemical modeling rather than engineering properties of soil are available in the market. These systems are made for higher performance and can be used to serve minimal purpose. But the cost per equipment including software and hardware is exorbitant. Our proposed process' cost is minimal and wins hands down in performance.

Currently *'Soil Engineering'* also has a system with a rugged tablet pc and bluetooth printer, which is quite expensive in comparison to our new approach (Soil Engineering, 2012). Besides in our proposed system it is not mandatory to purchase a dedicated hardware.. Hence minimal training and a financially feasible solution, is made possible.

Recording field data in any suitable software or customized excel installed in a laptop or tablet can be a solution for field logging. We also found some elaborate spreadsheets developed for field data collection on a tablet or laptop, including lookup lists, validation and VBA code. Purchasing & maintaining one additional expensive device for each drilling rig operator cannot be a feasible or convincing solution for field data management. Our focus is to make use of devices that the operator is inured to use and optimize usage. Moreover a rugged tablet pc with extended battery life and mobile connectivity & GPS is quite expensive. In such case, we decided to introduce our system, which will utilize the handy smart phones without compromising any convenience.

Basic Features of Smart Phones that we are making use in SFL

i. Camera: *For taking relevant Photographs of soil/ rock samples*
ii. Internet connectivity: *To Upload Data (Real Time)*
iii. GPS: *For site/ borehole location in Map (James, 1996)*
iv. Processor: *To process apposite raw data/ input*
v. Microphone: For Audio notes (in need)
vi. Multi touch screen: various gesture for better performance/ easiness

## 2 ANALYSIS

### 2.1 *The Need for a New Process, Systematized Field Logging*

To cognize the special requirements of our new system we sought to enumerate the features commonly required by professionals. Putting our experience to use, we have identified the common problems in conventional logging method and the rudimentary needs of innovations required in this field.

### 2.2 *Complete Data Logging*

Paucity of site data may be quite a big problem for professionals to use those incoherent data for modeling and design purposes. SFS is designed in such a way that the basic data is mandatory to proceed to the next stage. We have participated in many projects in Singapore and from our observations we have defined a rudimentary data set [Art. 3.3] that is deemed mandatory for site data logging.

### 2.3 *Improved Data input Technique*

Data Input in field using a small device may not be convenient for some professionals and workers who have been using papers to write for so long. To overcome this problem we got ourselves involved in field and observed the following,

i. The need of a system that is handy and easy to use without maintaining extra equipment. The SFL basically uses a handy medium with convenient input procedure.
ii. In paper based field log, the site personnel have to jot down the depth scale, legends for all kind of sampling & in-situ testing, repeat project details in each pages etc. SFS use all latest Human-Computer interaction techniques like screen transaction, drop-down menu, audio recording, etc. to ease this process for both expert & novice alike.

### 2.4 *Time & Location Information*

The location for each and every sampling or testing is of utmost importance. Till now there is no accepted way to record that data. Lack of proper equipment and qualified manpower renders it to be troublesome. SFL handles this problem by utilizing the in-built GPS on the smart devices. Location with time/date stamp of each sampling as well as in-situ testing is automatically recorded in the central database.

### 2.5 *Economically Feasible Solution for Innovative Field Logging*

In a considerably big project, site investigation work entails presence of experienced Geotechnical Professionals, Geologists, Engineering Consultants, Quality Surveyor, Site Supervisor & pertinent rig operating personnel. Close communication between them is an important factor for a standard project work. It is quite common that some in-situ testing or sampling, drilling depth etc. has not been included due to the paucity of real time communication. It is not always possible to engage above-mentioned professionals in a smaller project. In such instances, site supervisors end up monitoring several drilling rigs and produce adumbrated field logs, which are later rendered by experts for report generation. So our aim was to develop a process, which will not only standardize the field log but also obliterate the present limitations. Systematized Field Logging can basically be used in any available smart phones in order to ensure cost optimization. Using a smart phone offers flexibility and also confirms the familiar interface for field data input.

### 2.6 *Real Time Field Data Logging*

In SFL all recorded data from each field device is transmitted instanty to the central dedicated web server where it is automatically filed sequentially. The new system obliterates the need for retyping from hand written field sheets resulting in a quicker, more efficient turnaround of boring logs. This enables better-informed operational and technical decisions to be made.

## 3 DESIGN & IMPLEMENTATION

*Systematized Field Logging* is designed to run on Android based devices. The process can be presented in the following diagram.

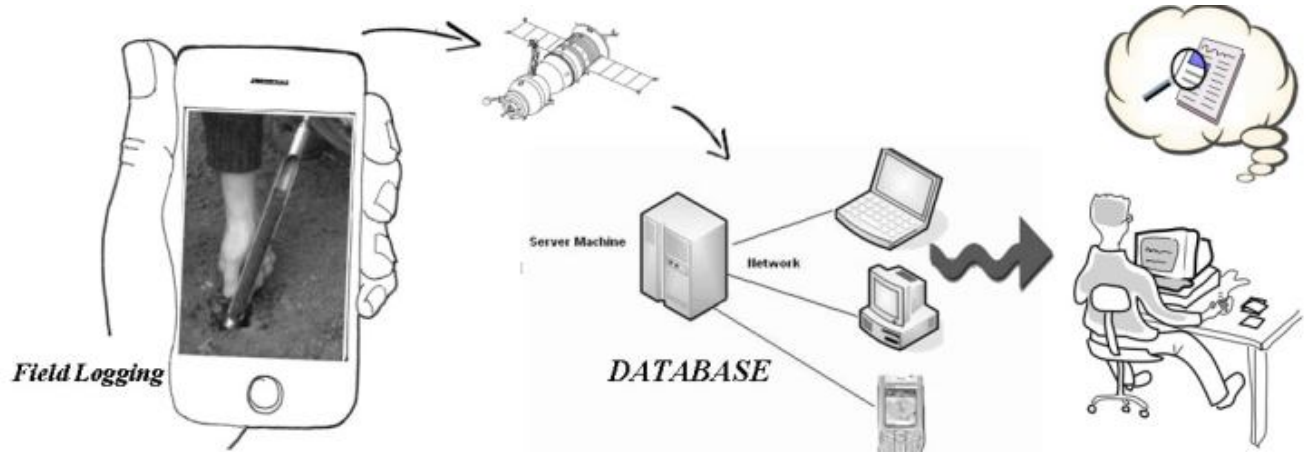


Figure 1. Thematic process flow of SmartField System

### 3.1 *General*

This unique process when put in place, helps the rig operator, to use a smart device and record the necessary data in a graphical input interface and take photographs - where required - of the soil, water or rock samples collected. Through the smart phone's inbuilt GPS the exact time and the location or as built coordinate of the borehole will be automatically recorded. As a field-based solution, which does not compromise data quality, SFL is designed to maximize efficiencies. This process technically does not need a dedicated device, thereby decreasing the cost of operations for the end user. The process can be downloaded into any smart device like mobile phones, tablet, laptop or personal computers, where no new software installation is required for viewing the web database.

The design of SFL as already mentioned is heavily influenced by our on-site and off-site work experiences. As a deliberate design decision we decided to work with a Human Interaction Specialist to ensure that the Graphic User Interface is easy to use. The on-site personnel who are involved (the rig operators or supervisors) are not qualified professionals. But they have to provide accurate data, which will enable professionals to arrive at an ideal conclusion.

### 3.2 *User Interface*

The program in the device prompts the user to fill up the apposite information and hence ensures that all data required for standardized reporting is collected directly at site. Drop down menu, preloaded texts & other features render easy and less time consuming data entry. In addition cogent features like 'field audio notes' and 'sample photograph' in field logging is something we added in our modified approach to facilitate an advanced database.

### 3.3 *Standardizing Field Input Data*

In our new approach we have standardized a common set of data we need to collect from field,

i. Basic Project details: Project Title, location, client name, consultant details etc.
ii. Basic borehole information: Type of investigation, reference number, survey information, automatic time & location and other pertinent information.
iii. Sampling Details: Depth, reference number, sampling type, photographs, audio notes, automatic time & location information.
iv. In-situ test details: Depth, reference number, type of test (from drop down menu), photographs, audio notes, automatic time & location information..
v. Termination of investigation: Termination depth with relevant information regarding the completion with automatic time & location information.

We understand that some geotechnical or geo-environmental investigation will have special data of interest. Again recorded data from site also needs to be scrutinized. In SFL, logged data is required to be published in the dedicated web database instantly so that relevant professionals for off-site verification/ validation can use it.

### 3.4 *Data Storage, Validation & Security*

The advanced data input program associates with data validation and ensures all expected field data is in. Chances of field data manipulation and off-site data generation are almost impossible. The real time field data/ photographs can be verified at any point of time. Besides, information on location & time for each input are recorded for additional security. For enhanced security and scrupulous data management each and every device is required to register using International Mobile Equipment Identity Number, better known as IMEI, including the user name prior to use on site for data recording (Shamikh, 2012).

Skipping of input is totally not supported in the system and the location will be tracked for every sampling or in-situ testing, making this unique. Consummated field logs will be generated within minimum time and can be displayed to relevant project officials instantaneously. Sample collection frequency, in-situ test, borehole termination depth and any required installation can be requested by the consultant/ client or specialist, any time.

### 3.5 *Geotechnical Work Database*

Our robust database ensures real time field log generation for relevant personnel who help in making necessary decisions. The preliminary data management system handles data securely allowing no room for data manipulation from site. Once the investigation terminates, the data will be secured in our database and site operator will have no access to alter the data. As per our design, only registered devices are allowed to contribute data to the database. In the same way, the end viewer can only view the data by secure log in (that confirms identification). The central administration will determine the access level of other users. The advanced system is designed to ensure continuous data uploading from various operators at a same time. Since data from a myriad of projects will be structurally stored in an organized way with adequate backup, chances of losing data is remote. The logging format can either be a simple excel using suitable templates or AGS or any other standard geotechnical formats which the contractor is comfortable with (AGS, 2006). This information is shared real time where a client, consultant or contractor, can check the progress of site work without actually visiting the site. A multiple user format, allows simultaneous works in various locations to be monitored at any given time.

### 3.6 *Contributing to a Better Environment*

Traditional data logging method requires a lot of copies of the same results to be generated, thereby consuming reams of paper for a considerably small project. Our new approach obliterates use of paper for logging purposes.

## 4 USER EVALUATION

Before our final study, we performed a pilot study with several users and owners of relevant companies in Singapore who gave us qualitative feedback, which we report here with other data. Our final study with a geotechnical company was both qualitative and quantitative, using a formal protocol designed to answer apposite questions:

### 4.1 *Participants and Environment*

Our formal study had ten participants, geotechnical engineering professionals and geologists. Among them, one is a professional engineer (Civil), four are engineers, three are geologists/ site supervisors and two are novice site drilling rig operators. 8 out of 10 users used it on site and reported that they used the system for their professional project.

### 4.2 *Method*

The formal evaluation process was conducted in the following three steps.

1) *Step 1:10 minutes.* Users were given no explanation and were told to test out *SFS*. This step helped us gauge the initial learnability of the system and users' initial impressions.

2) Step 2: *10–15 minutes*. Users given a brief description and demonstration of the features they didn't discover in step one followed by entering an example data set from a real project.

3) Step 3: *Practical task:* In the final step, users were asked to use the system either to use it for exploration or in their own projects. This step helped us assess users' preferred techniques, and it allowed us to observe professional use of *SFS*

At the end of the study, users were given a questionnaire and an interview was conducted.

### 4.3 *Results and Discussion*

Users' overall reaction was very positive. They found *SmartField System'*s UI intuitive and they were able to use the system for professional use in the allotted time they were given.

*Q1. How do users evaluate the fidelity and intuitiveness of SFL?*

Users liked both the application and server interface and indicated that it was very easy to learn: average-rating 4.5 on a scale of 1 (extremely difficult) to 5 (extremely easy). All users found the use in site and post reporting reliable. After a brief demonstration, users understood all features.

*Q2. Do users find the features of SFL useful and can they apply them effectively as a new medium for field logging?*

To better understand the relative merits of our features, we offered our system to users who are in charge of soil investigation sites in Singapore. We provided training before they started to use the system. The users were comfortable with the system. One user Mr Bala Subramanian, Manager from GIE Singapore said, "This system is peerless, saves time, quite handy in field and ensures best communication with field and office unlike any present method."

The system renders no facility for on-site personnel to manipulate data. Our features for data security made our system more reliable and are a big advantage for end-product client. Mr. Tan from Singapore mentioned, "I should ask my contractors to use this system for all Soil Investigation works."

*Q3. Is there evidence that SFL facilitates productivity?*

We found three classes of evidence to support this. The different input captured by *SFL* provides some initial evidence that it facilitates productivity. Inputs like photographs & voice notes inspired users to envision a radically new use that goes beyond traditional logging method. The intuitive design of the handheld application and the server was decidedly found to be superior to any traditional logging method. As Mr. Jerome from Commitnetz, Singapore said, *"I prefer the system for on-site use because it's so easy and quick."*

Secondly, it offers real time dexterity for on site and off-site personnel. We observed that when used our system ensures a better utilization of manpower for the project. On introducing this new approach Mr. Ahamad from Ground Engineering Singapore confirmed, "The system is impressive because our professionals can simultaneously supervise more projects meticulously and effectively."

Finally, we found that the overall system ensures the immediate availability of data without the need for re-typing allowing for a quicker and more efficient turnaround thus enabling better-informed operational and technical decisions to be made. Accessibility of data also impressed all of our users. Dr Chua Tong Seng, the President of the Geotechnical Society of Singapore added, "The whole system not only saves time for site personnel but also beneficial for designer and off-site professionals to whom this data accessibility means a lot."

The evaluation we have presented here has demonstrated the intuitiveness and the effectiveness of our new approach for all geotechnical investigation. It has also given us a deeper understanding of the affordances of this new system.

## 5 FUTURE WORKS

In future, we plan to integrate multi touch gestures associated with proper evaluation to utilize the most important features of smart devices. Finally, with the increasing popularity and ubiquity of smart devices using multifarious operating system (OS), we plan to deploy SFL for other OS and make it available for all geotechnical professionals.

## 6 CONCLUSIONS

The superiority of Systematized Field Logging lies in standardizing field logging with its cost-effectiveness and proven technical benefits. The user-friendly graphical interface and professional use of smart devices in the field of geotechnical engineering makes the system elegant. For the drillers SFL eliminates the extra time and effort of writing logs manually and allows more time for productive field activities. Real-time dexterity for both on-site and off-site personnel is a huge benefit. The immediate availability of data enables better-informed operational and technical decisions to be made, including budgetary controls. Benefits to the Client or Supervising Authority include quicker availability of fully compliant data, including suitable formats like excel or AGS. Furthermore, it is intelligible that the new system when deployed will decidedly develop a huge geotechnical database helping academics, private & government agencies for important analysis.

Producing this new medium required us to develop a new approach to real-time data recording interface in smart devices that confirms better human machine interaction at a very low usage fee. Our evaluation of SFL shows that we have succeeded. When we analyzed it in some soil investigation projects in Singapore, we found it to be an archetype that enhances both professionals' and novices' without the need for extensive training. Finally our process will decidedly confirm a reduction in paper consumption, saving few thousand trees and will contribute to a better World Environment.

## ACKNOWLEDGEMENT

In no small measures could we thank Mr. Rubaiat Habib, Human Computer Interaction Lab, National University of Singapore for his valuable contribution providing excellent user interface advice. We thank the geotechnical professionals who provided interviews, insightful comments, and permission to use their adept comments. We specially thank Mr. Kevin Quan, Mr. Mohiuddin Ahamad and other members in Ground Instrumentation & Engineering Pte Ltd for their unconditional and boundless support. Finally we thank the many reviewers (all of whom requested to remain anonymous) for their helpful comments. This research is fully funded by Agaze International Pte Ltd.

## REFERENCES

Hvorslev, M. J. 1949. Subsurface exploration and sampling of soils for civil engineering purposes

Bowles, Joseph E. (1996). *Foundation Analysis and Design*, 5th Ed., the McGraw-Hill Companies, New York. Ch. 12-3.2 pp. 668-670

Dataforensics, 2011, P-Log PDA-based Field Borehole & Well logging Software, http://www.dataforensics.net/

Soil Engineering, 2012, Digital Borehole logging for Ground Investigations, http://www.soil-engineering.co.uk.

James J S, 1996, The Global Positioning System: Theory and Application, Volume 1,American Institute of Aeronautics and Astronautics, Inc.

Shamikh F, 2012, Analysis of International Numbers of a Cell Phone. Journal of Information Systems and Communication ISSN: 0976-8742 & E-ISSN: 0976-8750, Volume 3, Issue 1, pp.-243-246.
AGS, 2006, AGS Data Transfer Format, Association of Geotechnical & Geo-environmental Specialist, www.ags.org.uk