Innovative Methods for Site Access and Insitu Testing of Impounded Ash Materials

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ABSTRACT

The US EPA Final Rule for the Disposal of Coal Combustion Residuals (CCRs) has an aggressive schedule for site assessment, design and construction of ash basin closure projects. Addressing these schedules presents unique challenges with obtaining accurate geotechnical information and accessing remote sections of project sites prior to the start of construction. To address these challenges, the authors have modified a wide variety of amphibious equipment to receive state of the art in-situ testing and sampling equipment. The combination results in specialized sampling rigs that can efficiently access challenging saturated ash basins to obtain high-quality in-situ geotechnical information. This technical paper and presentation explain the following:

- How the amphibious equipment is used to safely access remote areas of partially saturated ash basins for in-situ testing, surveys, and a wide variety of pre-construction testing.
- The utilization of the cone penetrometer (CPT), flat blade dilatometer (DMT), Van Den Berg vane shear device, and in-situ seismic shear wave testing for design and pre-construction monitoring.
- How utilizing stand-by amphibious support vehicles eliminates the need for access roads and significantly decreases the cost of subsurface investigations.

In addition to cost effective subsurface investigations, this innovative technology can be used for other ash basin closure construction needs. Other technology applications include:

- Cost effective material characterization for rare earth metals (REM) present in partially saturated ash basins and tailings ponds.
- Application of erosion control and dust control products over soft and partially saturated ash basins.
- Sampling of partially saturated ash basins for dredging and dewatering bench scale testing

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INTRODUCTION

As contractors and field engineers have started implementing a wide variety of closure designs for ash basins there is increasing awareness of the importance of having accurate and representative subsurface information for geotechnical stability and dewatering designs. Frequently, ash basin owners and design engineers are limited in the amount of geotechnical information that can be obtained prior to the construction because of ponded water and safety concerns for traditional sampling equipment. In areas where ash is crusted and higher than surrounding surface pools, the installation of access roads required for conventional sampling equipment is expensive and time consuming.

As ash basin closure contractors have started construction in these challenging areas a wide variety of new amphibious and low ground pressure equipment has been developed. This equipment has been developed to address stringent requirements for the health and safety, and personnel rescue considerations required by the owners of these impoundments (the electric power utilities). In addition to the sampling, this amphibious equipment has been developed so that other site access and specialty construction activities can be addressed.

The final area of new technology development is the modification of amphibious equipment to receive specialty in-situ geotechnical testing equipment that is able to measure the geotechnical properties of very wet/soft materials. This equipment includes the flat blade dilatometer (DMT), the CPT, the Van Den Berg Vane Shear, the BAT permeameter, and a variety of specialty sampling tools for obtaining lab samples. This equipment is designed to provide important in-situ geotechnical information at a lower cost per location on saturated ash impoundments than conventional equipment. The modified amphibious equipment has low ground pressure, in addition to being able to float in open water, so the equipment operates more effectively than conventional equipment. This technical paper provides a summary of how this new and innovative equipment can be used in a manner that increases the accuracy of in-situ geotechnical data, in addition to improving the representation of sampling areas within saturated ash basins.

PRIMARY MOTIVATION – BETTER INFORMATION WITH SAFER METHODS

Owners, engineers and contractors have been “pushing the envelope” in the area of pre-construction geotechnical testing of ash basins for the past 5 to 10 years. It has been recognized that some of the most challenging areas for design and construction are the partially saturated sections that typically make up 40 to 60 percent of the overall ash basin. In order to collect samples from these partially saturated areas, some owners and geotechnical engineers have constructed access roads so conventional sampling rigs can perform geotechnical testing and sample collection (Hardin, Falmezger, Amaya 2013 and Jewell, 2016). Other consulting engineers and ash basin owners have used barges to access open bodies of water within wet ash basins before they were drained, or focused on sampling areas of the ash basins that

were relatively dry and stable. A typical access road construction over soft/wet subgrade conditions to allow for conventional low ground pressure rigs and geotechnical testing is show below:

Step 1: Start of Access Road Geogrid and Bottom Ash

Step 2: Access Road to Center of Ash Basin

Step 3: LGP Drill Rigs and Testing on Access Roads

Cost of Access Roads for Sampling and Testing: Construction of geogrid reinforced access roads utilizing bottom ash or other granular construction materials is typically 40 to 60 percent, or more, of the overall cost of the conventional subsurface investigation program for wet/soft ash basin closure projects. These access roads are frequently constructed over partially saturated, or recently drained ash basins by contractors experienced with this type of construction. Since the softest and wettest sections are frequently located in the center, or difficult to access, sections of the ash basins, the cost of the access roads can easily exceed $150,000 to $250,000. The geotechnical testing program for a typical 40 to 50 acre basin is in the range of $80,000 to $120,000, not including the need for specialty lab testing to address seismic stability issues. A recent project that included seven (7) Standard Penetration Test borings, five (5) cone penetrometer tests (CPT), and $25,000 of lab testing cost over $300,000. The largest portion of these costs were for the construction of access roads for the conventional low ground pressure (LGP) sampling equipment.

A Safer, Lower Cost Approach: A new approach was developed to combine the accuracy of in-situ geotechnical testing equipment, with the advantages of specialty amphibious equipment for wet/soft ash basins. Geotechnical laboratory samples were also obtained to correlate the in-situ geotechnical test results to conventional coal ash and soil strength parameters for use in slope stability, settlement and seismic stability evaluations. The methods described in this paper and presentation are unique because of the following reasons:

- **Emphasis on Safety and Rescue from Remote Locations on Ash Basins:** Experience on ash basin construction projects in the past 3 years has provided experienced contractors and engineers with an understanding that timely access and egress to wet/soft areas of the site or areas with heavy vegetation is not easy. Since all electric power utilities have a strong focus on safety and timely rescue of workers from ash basins, the project team required at least two (2) amphibious vehicles to be on-site and operational at all times.

Photo 1: Tracked and Floating Tire Access Equipment – One Working, One Rescue

Photo 2: Floating Tire Rig with Full Service, In-situ Geotechnical Testing

- **Different Tracks and Interchangeable Equipment:** Creating this innovative and practical site access equipment for geotechnical testing required that the R.B. Jergens specialty equipment team, work closely with Roger Failmezger of Insitu Soil, Inc. The UNC Charlotte CALM Office provided quality assurance review of the overall approach to ensure that the new equipment addressed client needs. These project needs include application in a wide variety of climate and ash basin surface and subsurface conditions. One of the key items that is offered by this new approach is to have amphibious equipment on-site that utilizes different propulsion systems (i.e. flotation tires versus floating tracks), to minimize down time and account for changing conditions. See Photo 1.

- **Reasonable Cost – Daily Rate versus Unit Rate:** By listening carefully to the consultants and electric power utility professionals that will need this specialty equipment, it was determined that a daily rate versus and per boring or unit rate was often the best option to account for the unknown ash conditions and the cost of

the specialty amphibious equipment. This approach promoted collaboration between the contractor and owner to plan the work for the areas that would allow the sampling to be carried out as efficiently as possible. This approach resulted a safe execution of the work, with reasonable costs and high quality results.

- **Interchangeable Geotechnical and Permeability Test Equipment:** The project team recognized that geotechnical engineers with different design methods, and ash basin owners with different project needs will require a wide range of equipment to be available for any given project. To meet this objective, and still achieve the low equipment weight and site access objectives, a specially designed project platform was developed. The testing platform was designed to be transferred to different types of amphibious equipment, including amphibious track excavators, for sites with very challenging site access. See Photo 2.

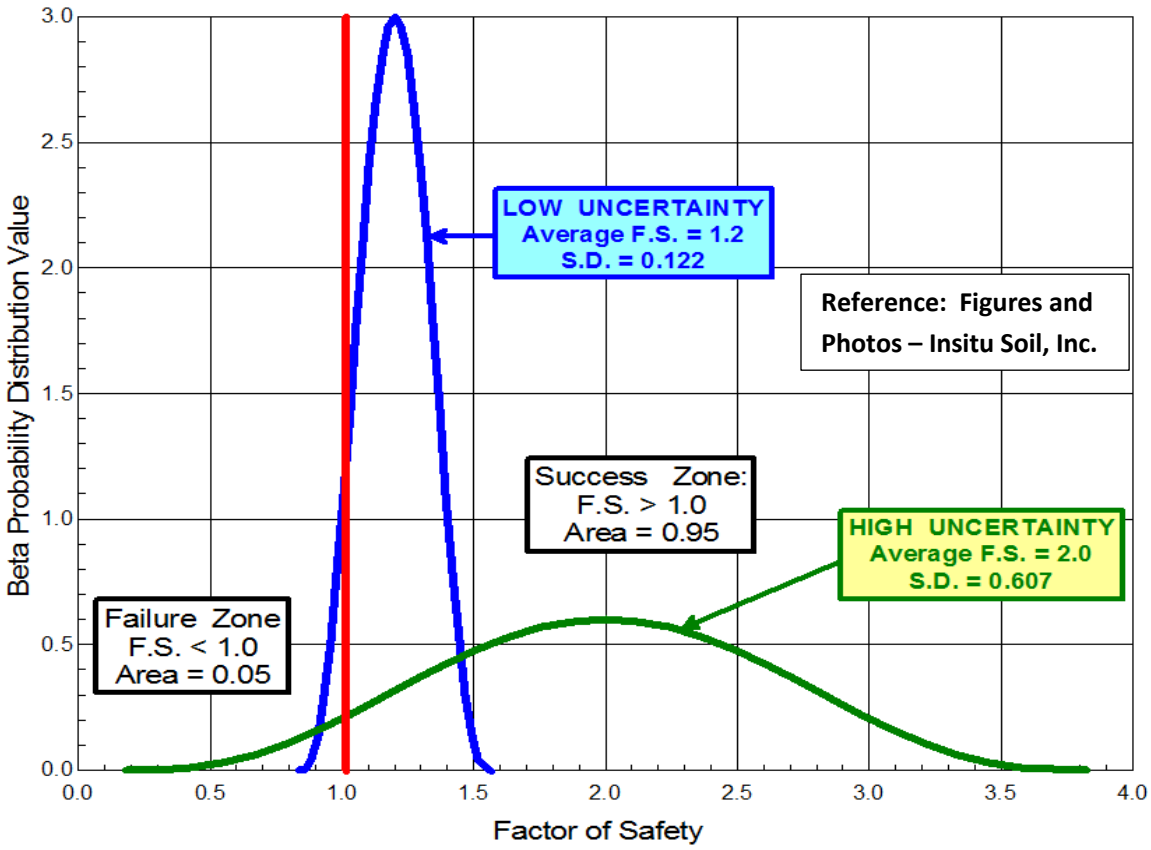
- **Access for Surveys, Personnel Transport and Rescue:** The innovative equipment has enhanced access and egress capabilities, and is flexible enough to allow re-configuration by R.B. Jergens and/or Insitu Soil for different types of geotechnical testing, groundwater pump tests and specialty sampling. Several of the innovative technologies are Patent Pending, but the overall purpose of the equipment and approach is to increase safety, improve the areas of ash basins that are sampled, while controlling the overall cost of sampling and testing of ash basins.

STATE OF THE ART GEOTECHNICAL TESTING AND SAMPLING

To address the unique challenges associated with testing and sample collection of wet ash materials the project team combined the in-situ testing expertise of Roger Falmezger of Insitu Soil, Inc., and the specialty construction equipment expertise of R.B. Jergens Contractors. The geotechnical testing and sampling equipment was developed to address several key items that are needed for a typical ash basin closure design:

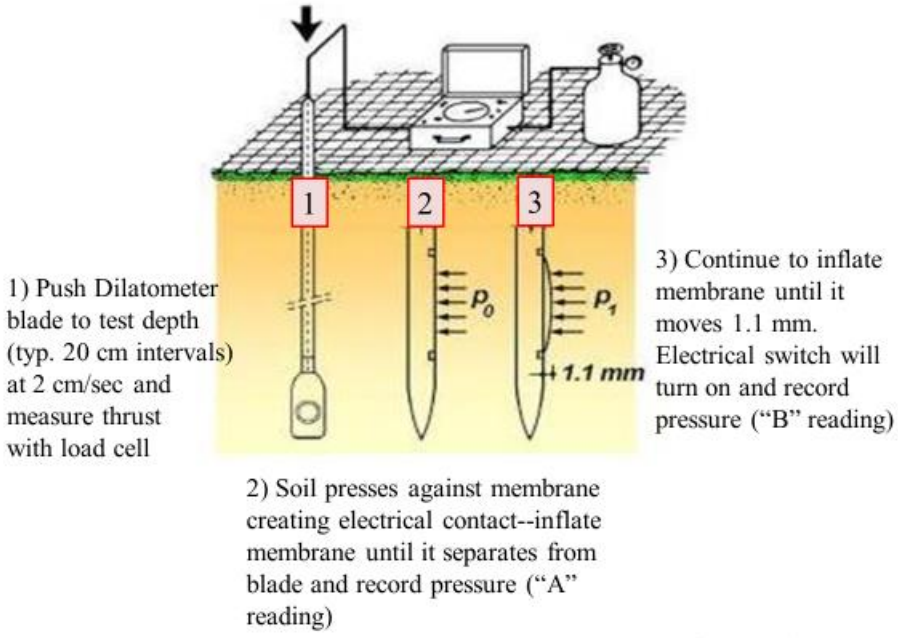
- Bearing Capacity and Global Stability – undrained shear strength, cohesion and internal friction of saturated materials
- Settlement Evaluation – stormwater channels and critical areas
- Slope Stability Analysis – interior ash basin and perimeter embankments, triaxial shear tests and in-situ shear strength parameters
- Seismic Stability and Liquefaction Potential – shear wave velocity for PC Shake, seismic coefficients for assessing liquefaction potential
- Coordination between geotechnical lab testing and in-situ test parameters
- Undrained shear strength parameters for interim loading condition and rapid drawdown evaluation.

The UNC Charlotte Coal Ash and Liquid Management (CALM) Office and Insitu Soil, Inc. worked together on the development of the innovative testing capabilities to develop **a "tool box" of geotechnical testing capabilities** that can be used for challenging ash basin closure projects. It is anticipated that many geotechnical engineers will only use a portion of the tools in the "tool box" because their companies already have some of these capabilities in-house. The overall purpose of the tool box of testing capabilities for wet/soft ash materials is to reduce uncertainty and better manage the cost of ash basin closure construction The figure below from Insitu Soil, Inc. provides a representation of these key principles.



A summary of the in-situ testing and sampling capabilities developed with the CALM Office and Insitu Soil, Inc. for specialty testing on ash basins are summarized below:

- **Combined use of the cone penetrometer (CPT), flat blade dilatometer (DMT):** The CPT is a cost effective method to provide valuable information about the layers and overall strength of the coal ash in wet ash basins. The results can be correlated to existing databases on other fine grained materials. One limitation is that wet ash materials are influenced by the dynamic action of the CPT probe that may provide inconsistent results. The DMT has provided accurate estimates of the settlement of silt-sized materials and ash materials in partially saturated conditions. In addition, the DMT can be used to provide correlation coefficients for the CPT that can be used to increase the accuracy of the overall geotechnical testing program. One limitation of the DMT is that it may not be readily available to geotechnical engineers in some locations, and it requires interpretation with some materials by a geotechnical engineer experienced with Schmertmann and Marchetti's methods.



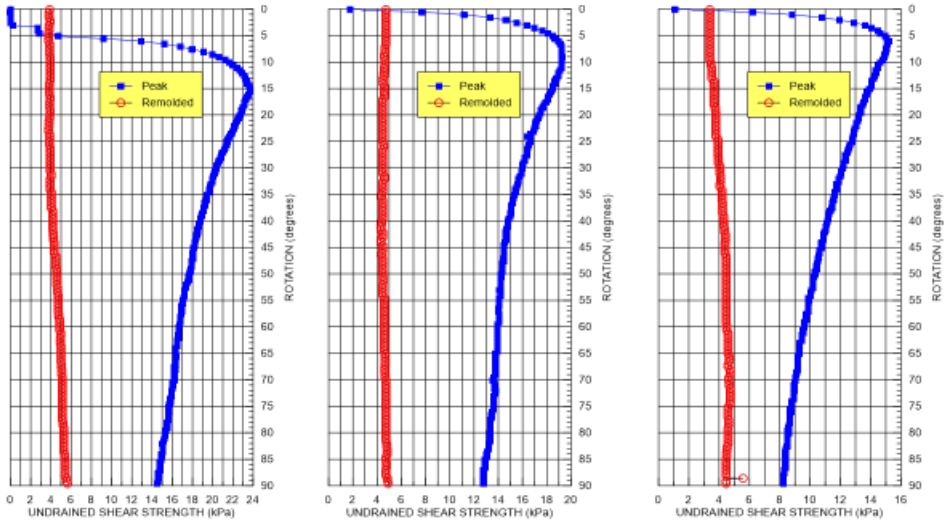
(After Marchetti, 1996)

- **Van Den Berg vane shear device:** The Van Den Berg vane shear device (VSD) provides useful information about undrained shear strength. This information can be correlated to unconsolidated undrained (UU), consolidated undrained (CU) and consolidated drained (CD) laboratory test results that represent the different stages of strength that are encountered at various stages of ash basin closure. The results from the VSD provide valuable information that can be used by field engineers and contractor quality control agencies to assess the interim stability of partially saturated ash basin excavations and embankments. Recent correlations between the Van Den Berg vane shear device and the hand held vane shear (HVS) device provide information that is essential for contractors to assess stability of ash basins during construction.

Humboldt Hand Held Vane Shear Test Device

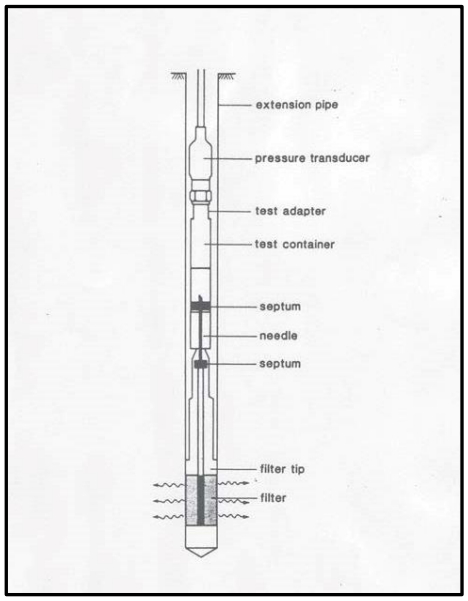
Van den Berg Icone Vane Shear Test Device

Typical Shear Test Results



5 Feet 10 Feet 15 Feet

- **BAT Permeameter Permeability Testing:** This specialty test device is designed to provide inflow and outflow testing of the combined vertical and horizontal permeability of porous media similar to fly ash and mine tailings. The results of the BAT Permeability can be useful for sizing of dewatering systems and/or identify the locations where pump tests will be performed.



OTHER APPLICATIONS FOR ASH BASIN CLOSURE

The ability to access wet and partially saturated ash basins safely and without having to building access roads provides opportunities for closure design, construction and beneficial use. The specialty equipment developed by R.B. Jergens Contractors and Insitu Soil, Inc. can be used in the following ways:

- **Characterization for rare earth metals (REM) present in partially saturated ash basins and tailings ponds:** This would include obtaining samples at 5 foot intervals to accurately evaluate the percentage of REM across the entire ash basin.
- **Application of erosion control and dust control products:** After an ash basin is dewatered, but prior to covering with soil or synthetic cover there is increased potential for erosion and dust emissions. The interchangeable bed developed by R.B. Jergens Contractors can be used in a wide variety of sampling, testing and construction applications over soft and partially saturated ash basins. Several of these applications are Patent Pending, and additional information can be provided upon request.
- **Sampling of ash basins for dredging and dewatering bench scale tests:** The portions of ash basins that require dewatering and/or could be acceptable for low water volume dredging are typically located in partially saturated areas. The ability to access these areas for sampling without having to build access roads can allow owners and engineers to obtain large samples during the feasibility or pre-construction phase.

SUMMARY AND CONCLUSIONS

The innovative methods for site access and in-situ testing of impounded ash materials described in this paper and presentation are available for use by ash basin owners, engineers and contractors in a wide variety of applications. Important geotechnical information for ash basin closures can now be obtained in a manner that is more cost effective and safer than methods that have been utilized on previous ash basin closure projects.

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