

**RESEARCH PROBLEM STATEMENT**

<b>DATE:</b> 09/06/2019	<b>PROJECT AREA:</b> Materials
<b>TITLE:</b> Investigating Rapid Soil Moisture Content Determination Methods	
<b>PROBLEM STATEMENT:</b>	
<p>Moisture content is a critical parameter that must be carefully controlled during earthwork operations to ensure the proper performance of fills and subgrades. Conventional methods (e.g., oven drying, pan drying, nuclear gauge) are not always reliable, may cause delays in construction, and may require special certifications, handling, and radiation monitoring. While the nuclear gauge has become very popular due to the ability to easily and rapidly obtain both moisture content and density, the regulations and handling requirements make it a hassle to own and operate. There is a need for a method which is just as reliable as the nuclear gauge without all of the regulatory burdens. There are a number of existing studies which have demonstrated the benefits of technologies such as time domain reflectometry (TDR), capacitance measurements, tensiometers, and resistance measurements. However, most of these studies only considered one or two soil types and very little priority was given to methods that do not require soil specific calibrations (which makes many methods time prohibitive). A thorough review of all the promising methods is needed which takes these factors into account.</p>	
<b>OBJECTIVES:</b>	
<ol style="list-style-type: none"> <li>1. Evaluate all of the promising methods from existing studies in the literature, as well as emerging technologies not yet applied to determine accuracy and ease of use.</li> <li>2. Determine the most accurate and rapid method or combination of methods.</li> <li>3. Develop testing and procedure manual and training module.</li> </ol>	
<b>FORM OF RESEARCH IMPLEMENTATION AND RETURN ON INVESTMENT:</b>	
<ol style="list-style-type: none"> <li>1. Operator's manual detailing method, procedures, and details needed to perform selected techniques.</li> <li>2. Field ready measurement system to perform moisture content and density determination.</li> <li>3. Training module and on-site training for use of equipment and procedures.</li> </ol>	
<b>Estimated Project Duration:</b> 24 Months	
<b>PREPARED BY:</b> Michelle L. Bernhardt-Barry	
<b>AGENCY:</b> University of Arkansas	
<b>PHONE:</b> (479) 575-6027	<b>REVIEWER:</b>

Standing Subcommittee  
Ranking

Advisory Council  
Ranking

Statement Combined with  
Statement Number(s)

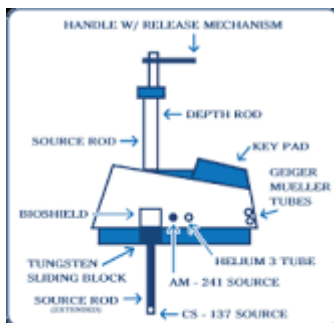
# Investigating Rapid Moisture Content Determination Methods

ARDOT Problem Statements FY-2021

**Moisture Content** is one of the most critical parameters for proper performance of fills and subgrades.

## Conventional Methods

- Oven drying
  - very accurate
  - takes 24 hours which delays construction
  - requires removal of sample which is labor intensive
- Pan drying
  - faster version of oven drying, but still takes extended amounts of time
  - not as accurate
  - requires constant attention/labor intensive
- Nuclear density gauge
  - not as accurate or reliable as oven drying
  - obtain moisture content and density quickly and easily
  - most commonly used method because of ease



## Disadvantages of Nuclear Gauge

- Radioactive source could pose a potential hazard if not properly used
- Requires regulations for transportation, use, and storage
- Training and logging regulations are time intensive
- Ensuring compliance with regulations can require additional resources and time

There is a need for a method that is as reliable as the nuclear gauge without all of the regulatory hassles and concerns.

# Other Emerging Methods

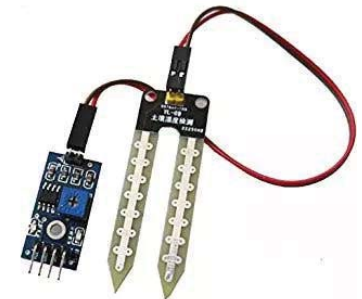
- **Electrical Density Gauge (EDG)**
  - measures density and moisture content without a nuclear source
  - requires separate calibration with each material tested
- **Time Domain Reflectometry (TDR)**
  - measures travel time of electrical pulse and relates it to dielectric constant of the soil
  - requires separate calibration with each material tested
- **Capacitance sensors**
  - measures resonant frequency which relates to a soils dielectric constant
  - requires separate calibration with each material tested
- **Resistive sensors**
  - measures current passing across probes which relates to the resistance value
  - requires information about the soil at different moisture contents in order to achieve a specific value



Capacitance sensor



Resistive sensor



## Research Goal and Objectives

**The goal of this study is to develop a rapid method to obtain moisture and density for different soil types during earthwork operations.**

- Evaluate all of the promising methods from existing studies in the literature, as well as emerging technologies not yet applied to determine accuracy and ease of use.
- Determine the most accurate and rapid method or combination of methods.
- Develop testing and procedure manual and training module.

## Proposed Research Tasks

---

1. Conduct a review of all existing devices and methods which show promise in rapid determination of moisture content and density
  - Moisture content determination is the main goal, but the final method must also provide density results too in order to compete with (and replace) the nuclear density gauge
2. Compare the accuracy and speed of the methods obtained in step 1 with the nuclear density gauge and oven drying method
  - At least 5 soils will be tested at a range of water contents (gravel clay mixture, sand, sand clay mixture, lean clay, high plasticity clay)
  - Calibration difficulty and time will be factored into these times and priority will be given to simple systems which do not require soil specific calibrations
3. Choose the most efficient and accurate method or combination of methods to achieve rapid moisture content readings
  - It may require a combination of methods for which a sensor system will be developed for use by ARDOT
4. Develop a measurement system, corresponding operator's procedure manual, and training module for use of the system

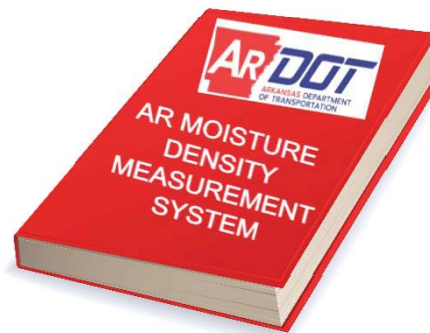
# Implementation and Deliverables

---

- Operator's Procedure Manual detailing method(s), procedures, and items needed to perform selected techniques
- Field ready measurement system to perform moisture content and density determination
- Training module, as well as on-site training for use of equipment and procedures



Moisture/density system



Operator's manual



- Reduce regulatory requirements of nuclear gauge
- Save time and money