

DEMONSTRATION PROJECT TO ASSESS THE TECHNICAL AND ECONOMIC VIABILITY OF USING TIRE DERIVED AGGREGATE (TDA) AS BACKFILL FOR RESIDENTIAL HOMES' BASEMENTS IN MANITOBA

Shokry Rashwan, Ph.D., P.Eng.
Paul Charette-Manitoba Applied Research Chair in Sustainable
Construction

School of Construction and Engineering Technologies
Red River College
A141- 2055 Notre Dame Avenue,
Winnipeg, Manitoba R3H 0J9

Peter Schroedter
OTR Recycling / Resolute Rubber
P.O. Box 660, Ashern, MB R0C 2E0

Brett Eckstein
Executive Director
Tire Stewardship Manitoba Unit B -
1791 Dublin Avenue,
Winnipeg, MB R3H 1A9

**OCTOBER 6TH,
2016**

Presentation Content

1. Background & Project Phases
2. Summary Results of Phases I & II
3. Up to Date Results of Phase III
4. Next Step

Background

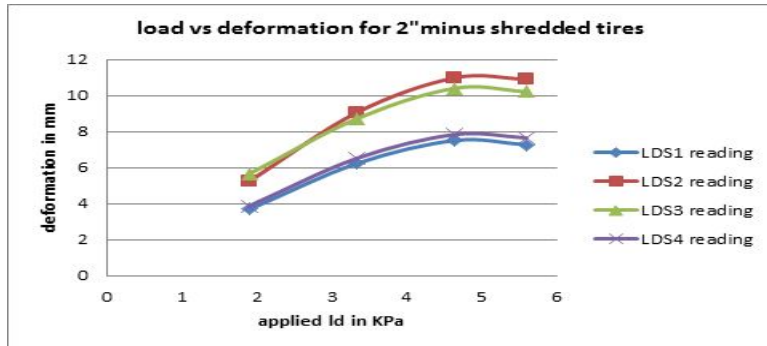
...since May 2013 the research team at Red River College (RRC) has been working with the Tire Stewardship Manitoba (TSM), OTR Corp and Manitoba Hydro on a research project to explore a “new” application for recycled tires known as Off-The-Road Tire Derived Aggregate (TDA)

Project was divided into three phases; Phases I & II focusing on short-term and Phase III focusing on long-term properties of the material

Summary of Results for Phases I & II

First: Compressibility

- “Compacted” 2”, 4” or 6” layer of TDA would compress 15% to 20% under DL (2.4 kPa)
- Additional 5% compression may result from applying LL of up to 4.8 kPa
- Permanent deformation after removal



Summary of Results for Phases I & II

Second: Gradation Distribution



Gilson large screen shaker

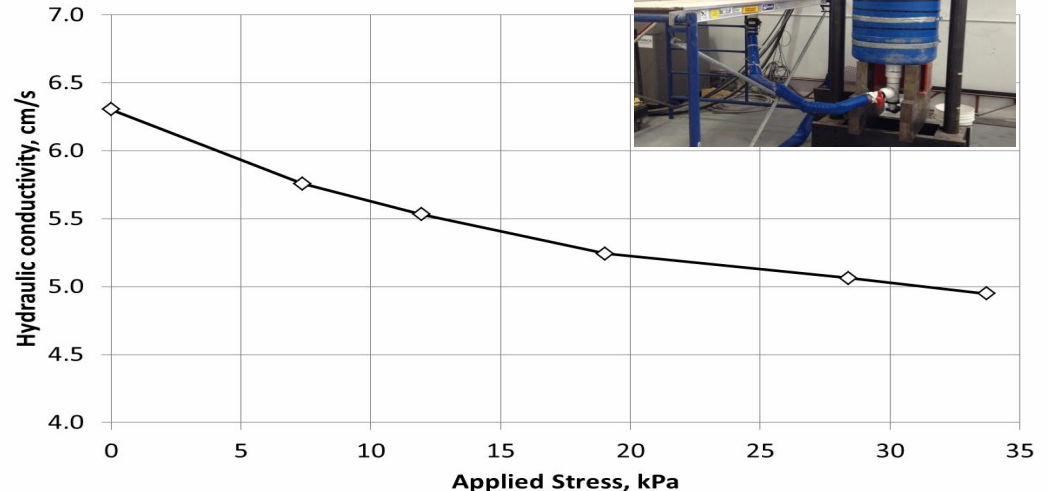


Summary of Results for Phases I & II

Third: Hydraulic Conductivity

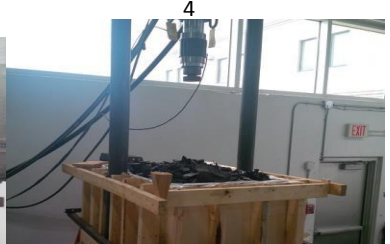
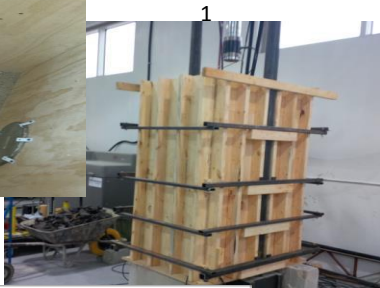
Hydraulic conductivity is the property of the TDA that describes the ease with which water can move through its voids

| Hydraulic Conductivity With No Applied Load (cm/s) | |
|--|--------|
| Tire Shreds | 6.3050 |
| Gravel | 3.0000 |
| Coarse sand | 0.6000 |
| Medium sand | 0.0500 |
| Fine sand | 0.0200 |
| Silt, loess | 0.0020 |
| Till | 0.0002 |



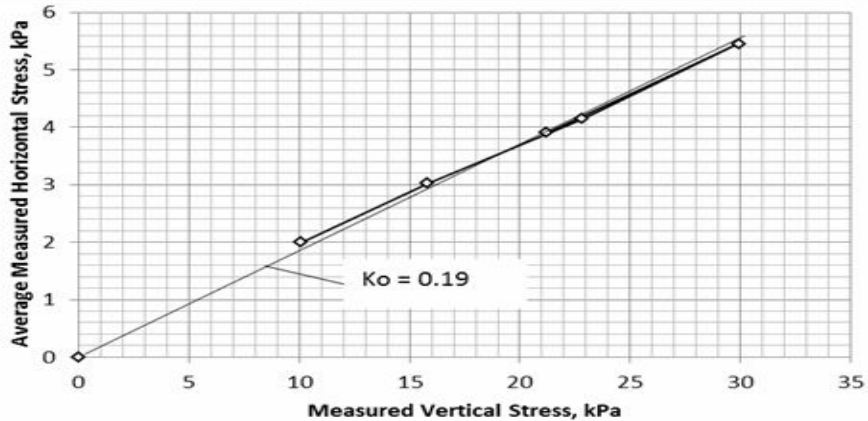
Summary of Results for Phases I & II

Fourth: Lateral Pressure



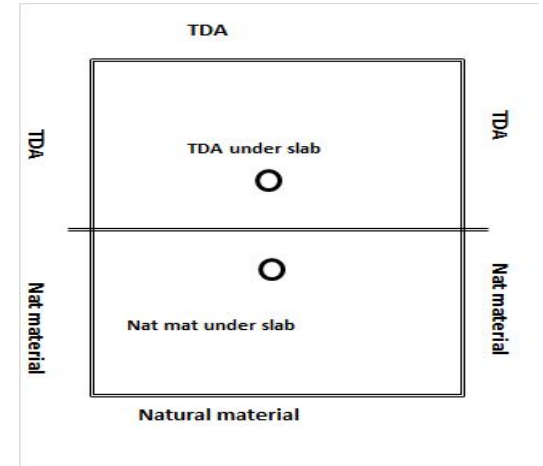
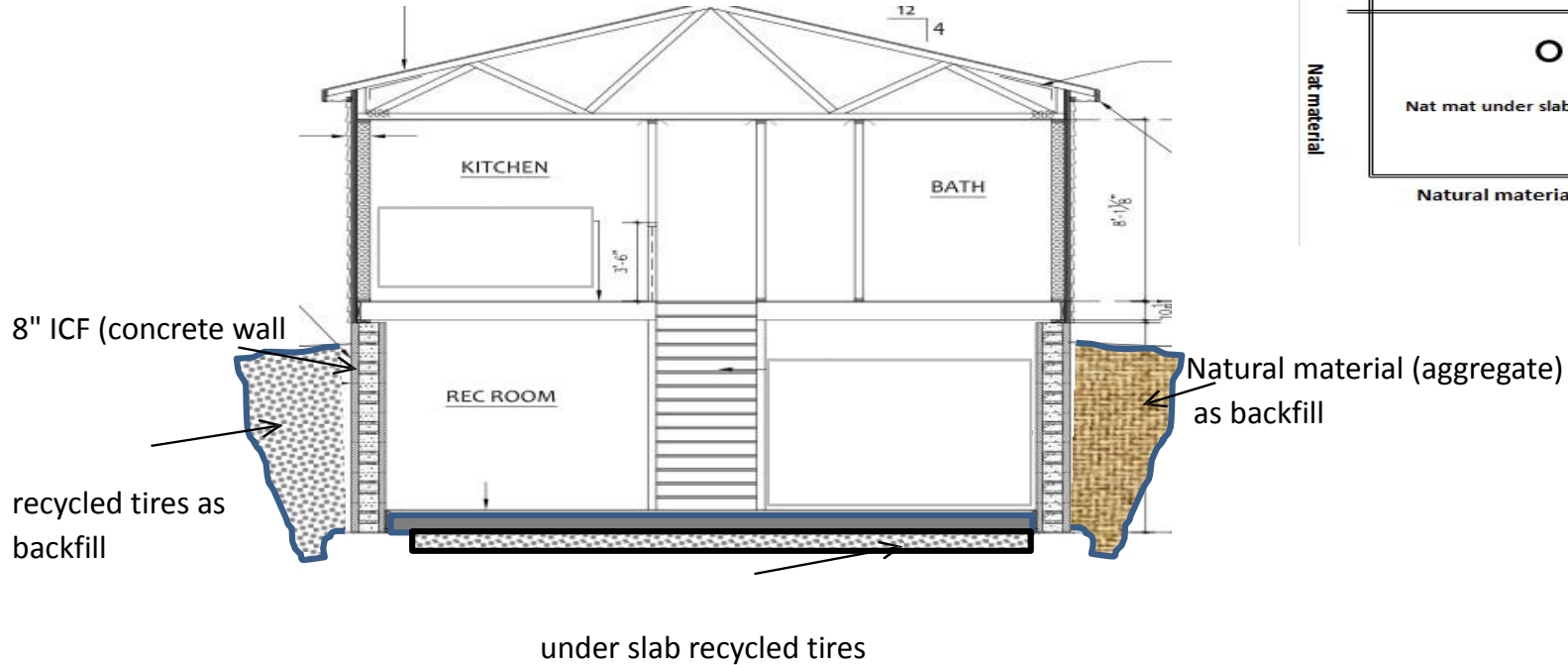
pressure cells reading

4" concrete slab laid on top of TDA



The results indicate a K_o value of 0.19, which can be compared with a K_o of between 0.35 and 0.65 for natural granular material.

Phase III



The research question for Phase III:

How does TDA perform in comparison with natural material, when used in home basement

Phase III

...Construction began in September 2015



Phase III



the concrete base of the wall separating the two sides of the basement



DATE: REVISION
15-11-24 ISSUED FOR CONSTRUCTION

KEY NOTES

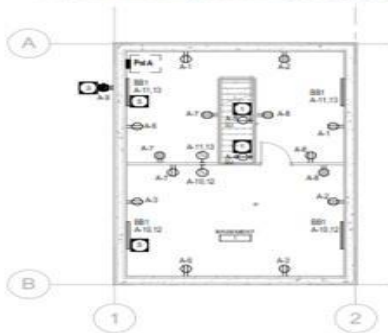
1. COORDINATE EXACT LOCATION OF PUMP RECEPTACLES WITH SLUMP PITS.
2. COORDINATE SWITCH/LOGIC AT TOP OF STAIRS.
3. COORDINATE LOCATION OF EXTERIOR RECEPTACLE ON SITE WITH OWNER PRIOR TO POULDER.
4. METER SOCKETS ON TEMPORARY SERVICE POLE. POLE SHALL BE SUPPLIED AND INSTALLED BY THE OWNER.
5. PROVIDE REMOTE THERMOSTAT MOUNTED ON WALL.

Design and specifications, as instruments of service are the property of the architect. The copyright in the same shall remain to the architect. No reproduction may be made without the permission of the architect and when such reproduction is made, all credit shall be referred to the architect. The contractor shall verify dimensions and quantities shown with conditions on the site and is held responsible for reporting any discrepancy to the architect for adjustment. This drawing shall not be used for building performance and construction by.

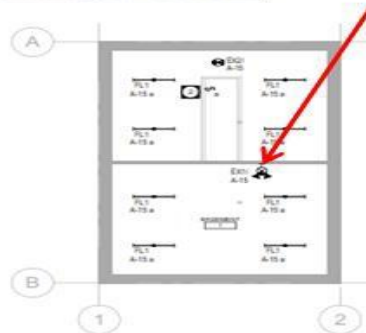
DATE: REVISION

epp siepmann engineering inc.
mechanical & electrical engineer
100-100 Avenue St. Louis
St. Louis, MB
439-444-1188

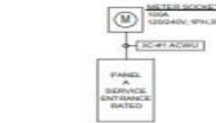
PROJ. NO.



1 POWER LAYOUT
E1.1 SCALE: 1:100

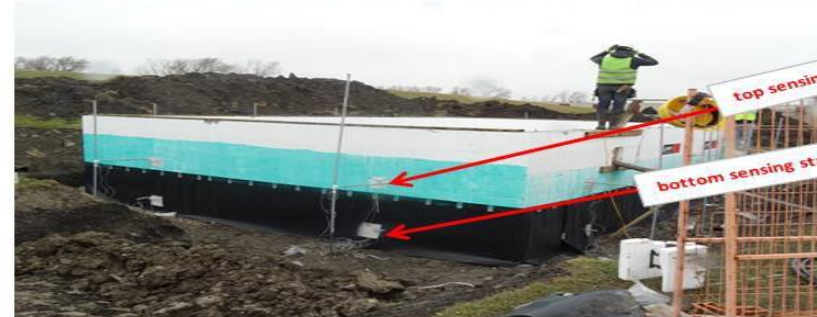
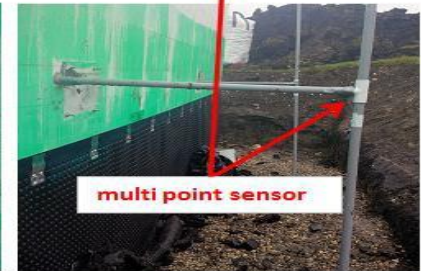
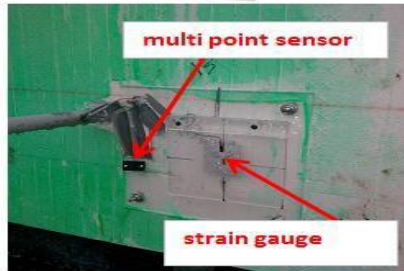
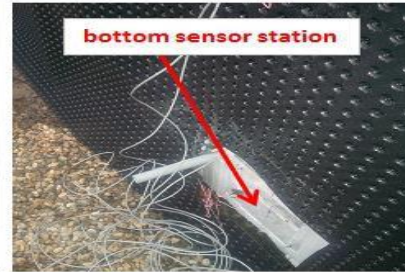
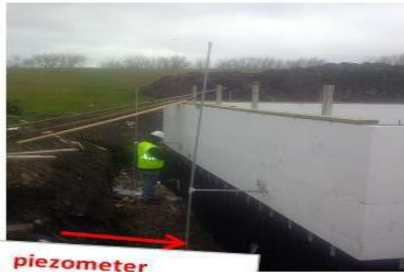


2 LIGHTING LAYOUT
E1.1 SCALE: 1:100



3 ELECTRICAL SLD
E1.1 SCALE: NTS

Phase III



Phase III



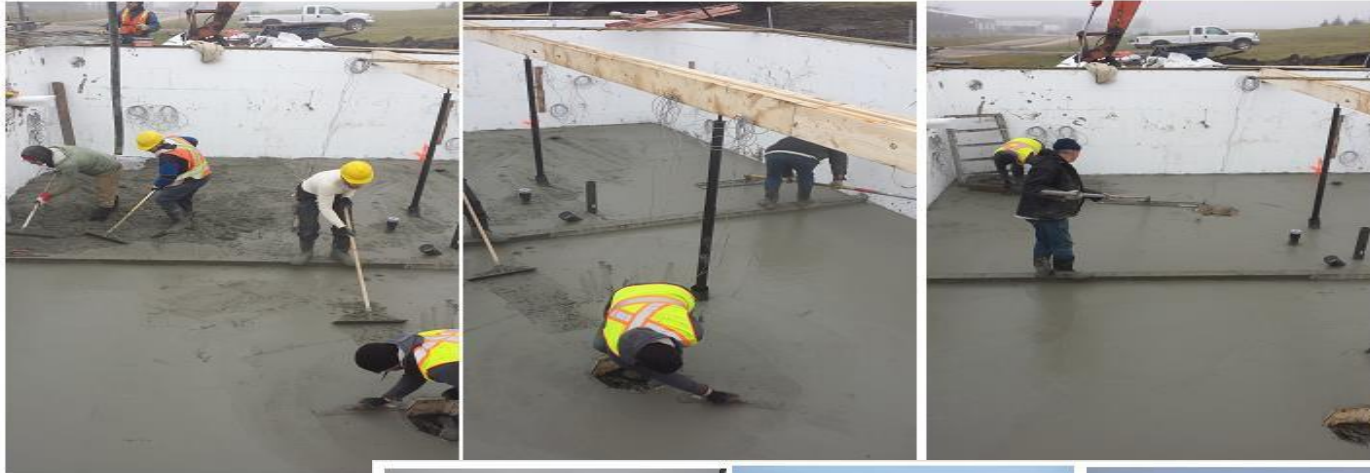
Backfilling with TDA

Phase III



placing TDA in the southern half and natural material on the northern half of the ground

Phase III



Framing of the floor joists

Phase III



Phase III

....Construction completed in January 2016



EXPERIMENTAL HOUSE PROJECT

This project is part of the activities conducted under the mandate of the
PAUL CHARETTE - MANITOBA APPLIED RESEARCH CHAIR IN SUSTAINABLE CONSTRUCTION

The project is a collaboration between the following:

OTR Recycling Corporation

- A-OK Construction
- All Star Concrete 2011 Ltd.
- Epp Siepman Engineering Inc.
- ft3 Architecture Landscape Interior Design
- Industrial Research Assistance Program
- Lavergne Draward & Associates

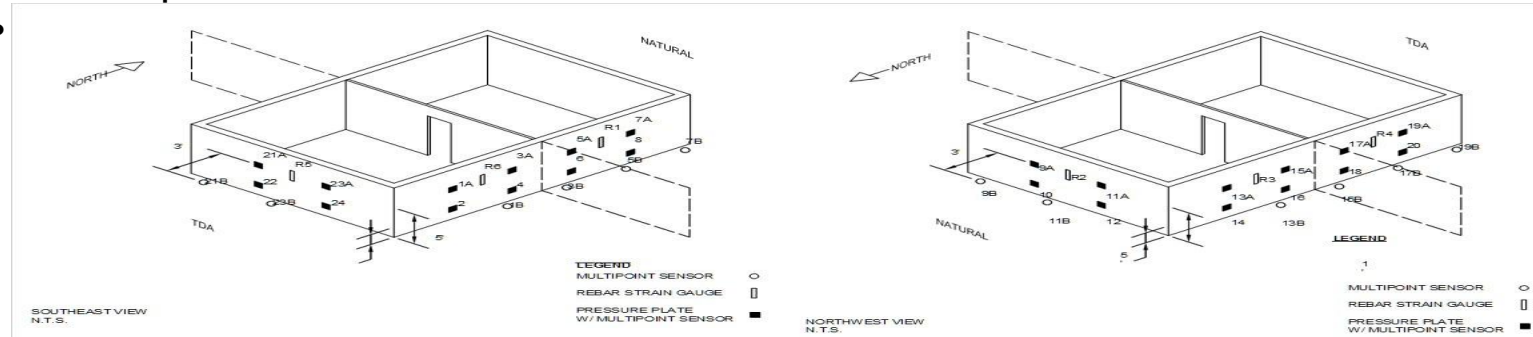
Tire Stewardship Manitoba

- Logix ICF/AMC Foam Technologies Inc.
- Manitoba Hydro
- Radonmatters
- Red River College School of Construction and Engineering Technologies
- SMT Research Ltd.

Phase III

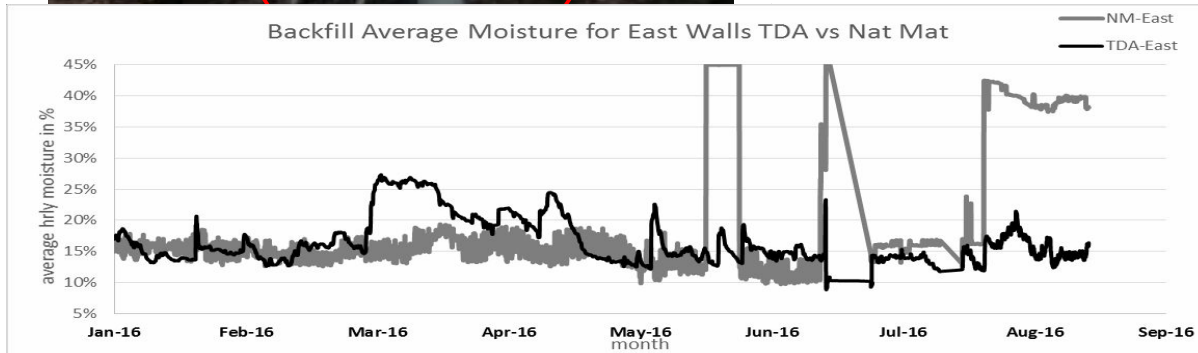
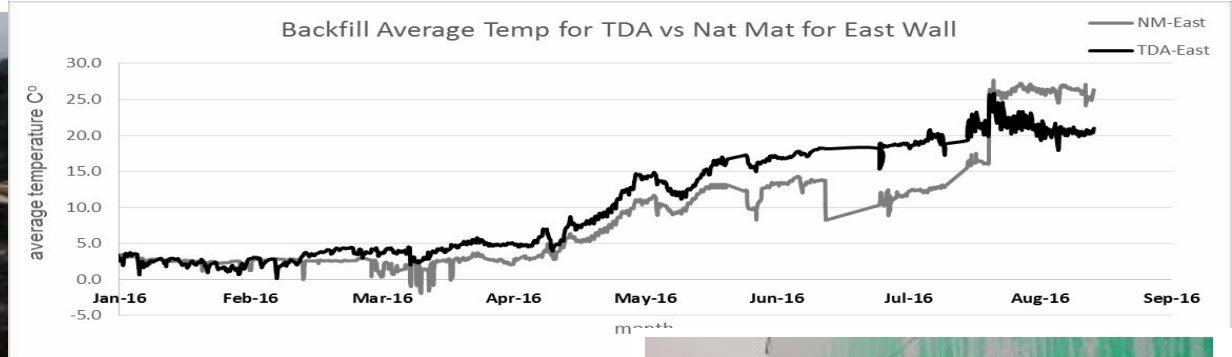
What's measured??

- Heat losses
- Moisture migration
- Drainage ability
- Lateral pressure on walls
- Differential movements of slab
- Radon levels
- Ground water qualities
- Flash point



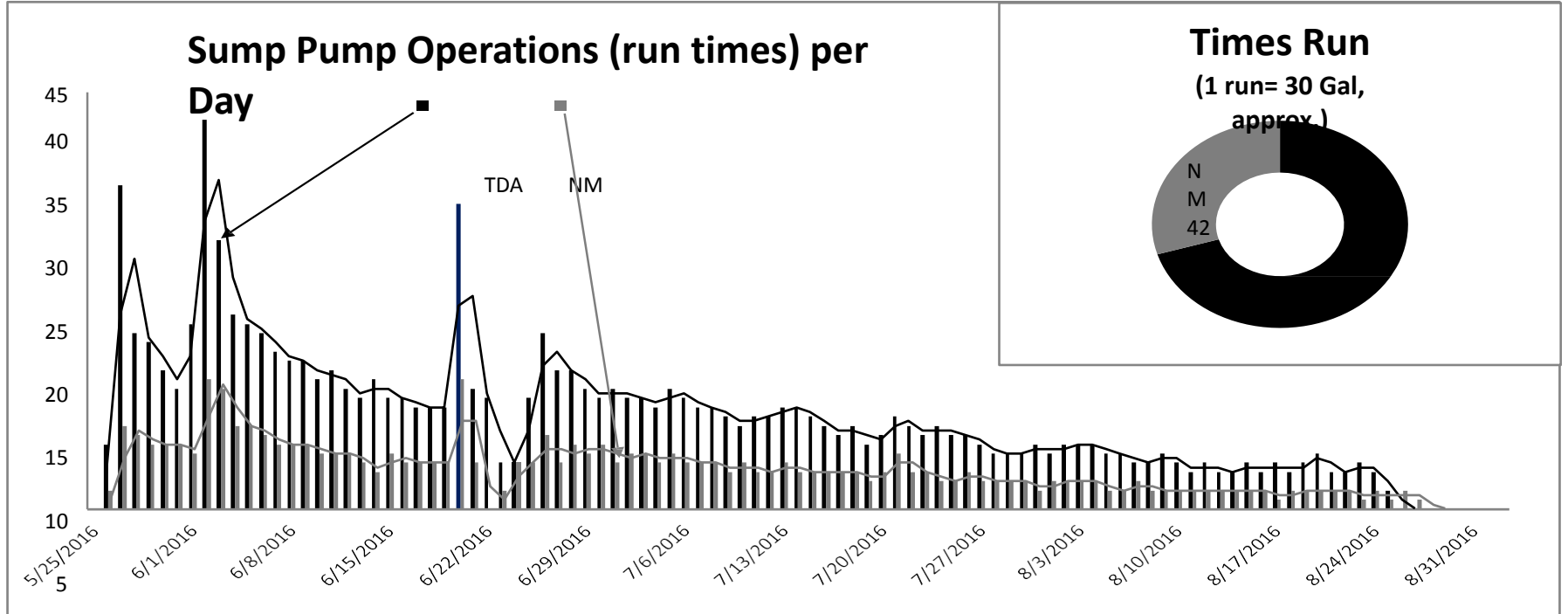
Phase III

Temperature & moisture measurements



Phase III

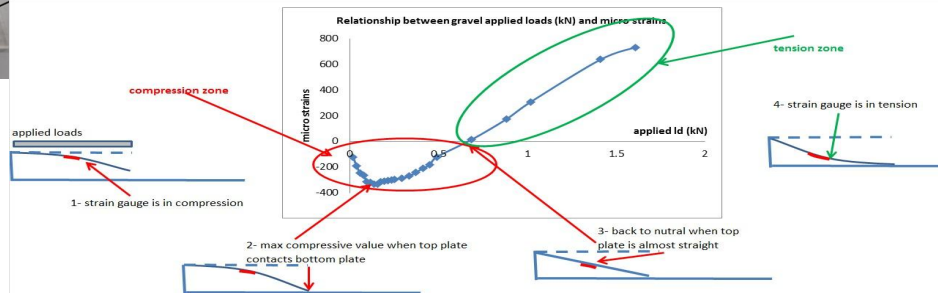
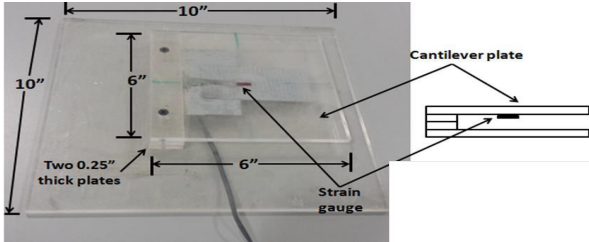
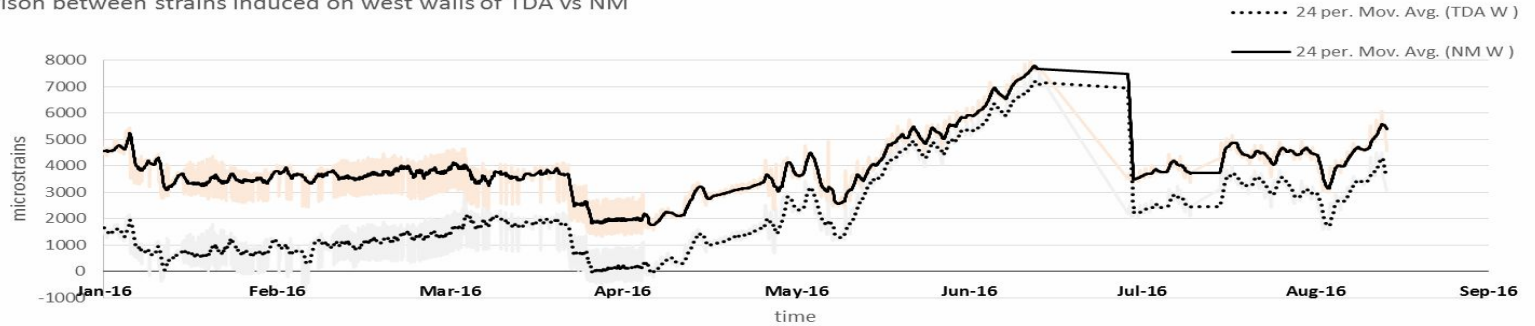
Drainage ability



Phase III

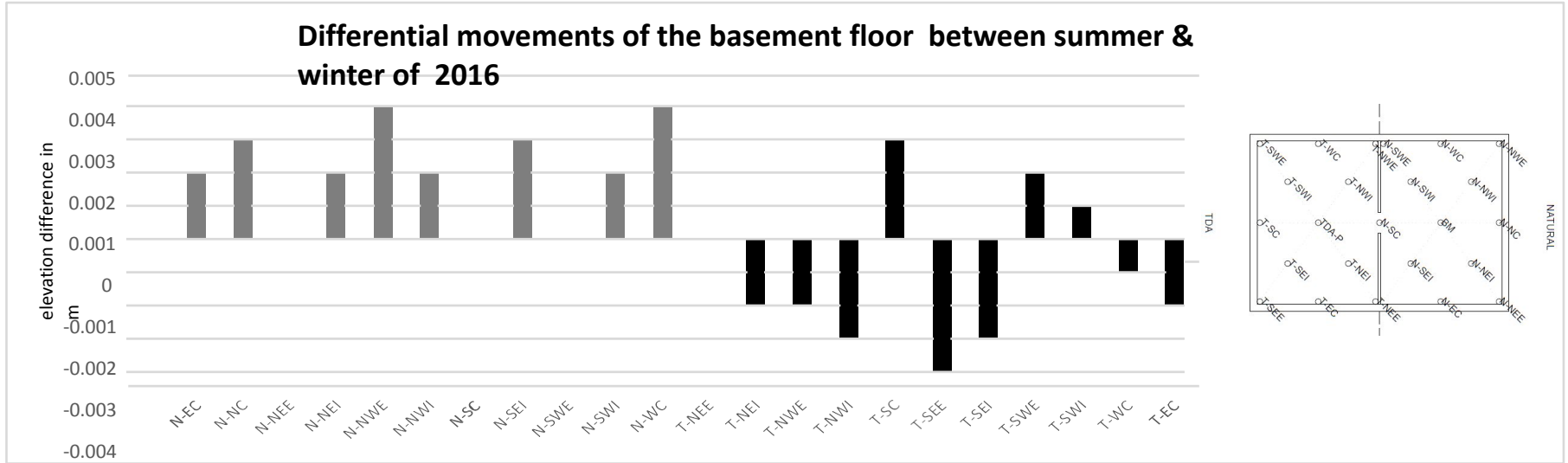
Lateral pressure on walls

Comparison between strains induced on west walls of TDA vs NM



Phase III

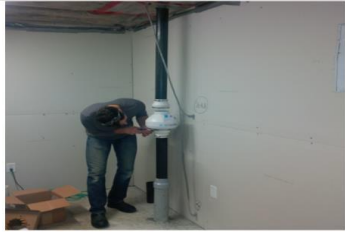
Differential movements of the slab



floor stations

Phase III

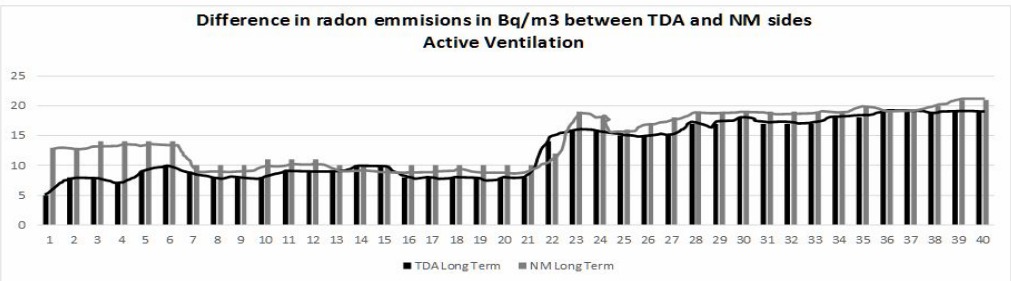
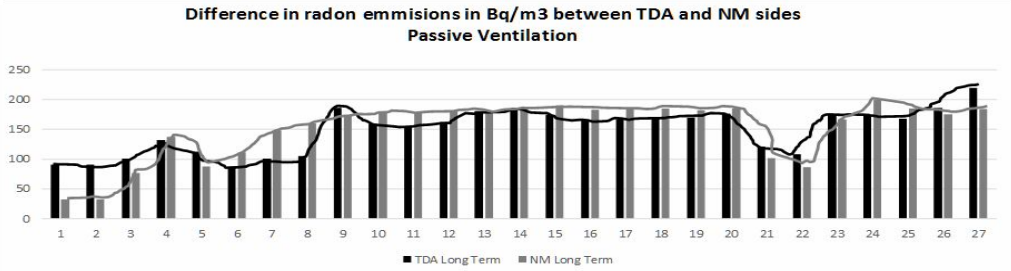
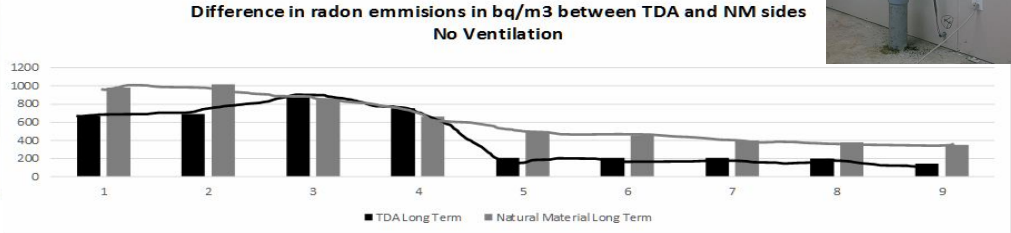
Radon levels



installing fan for active ventilation



passive ventilation. Notice the significant difference in pressure difference on the TDA side (right) compared to the difference on the nat material side (left)



| | N | Mean | StDev |
|-------------|-----|------|-------|
| all-active | 522 | 22.2 | 17.4 |
| all-passive | 530 | 83.1 | 39.9 |

T-Test of difference = 0 (vs not =): P-Value = 0.000 < 0.05

| | N | Mean | StDev |
|------------|-----|-------|-------|
| all-active | 522 | 22.2 | 17.4 |
| all-capped | 612 | 146.5 | 73.8 |

T-Test of difference = 0 (vs not =): P-Value = 0.000 < 0.05

| | N | Mean | StDev |
|-------------|-----|-------|-------|
| all-capped | 612 | 146.5 | 73.8 |
| all-passive | 530 | 83.1 | 39.9 |

T-Test of difference = 0 (vs not =): P-Value = 0.000 < 0.05

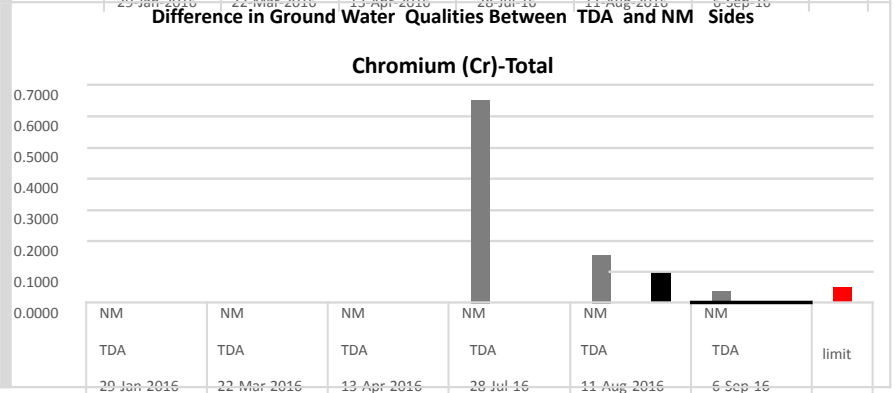
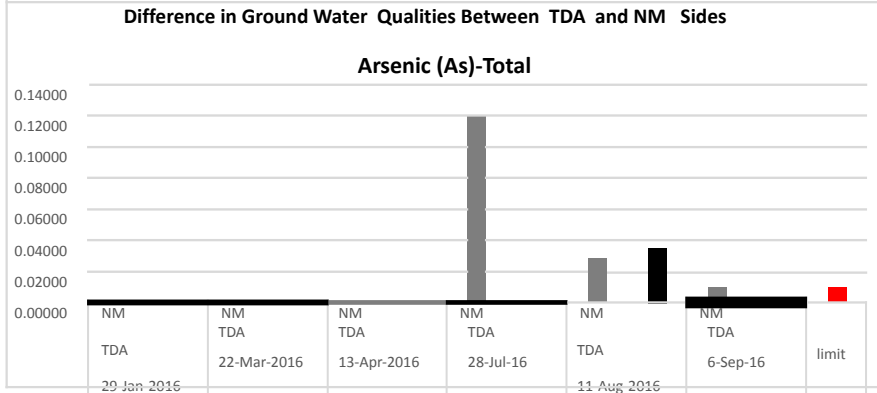
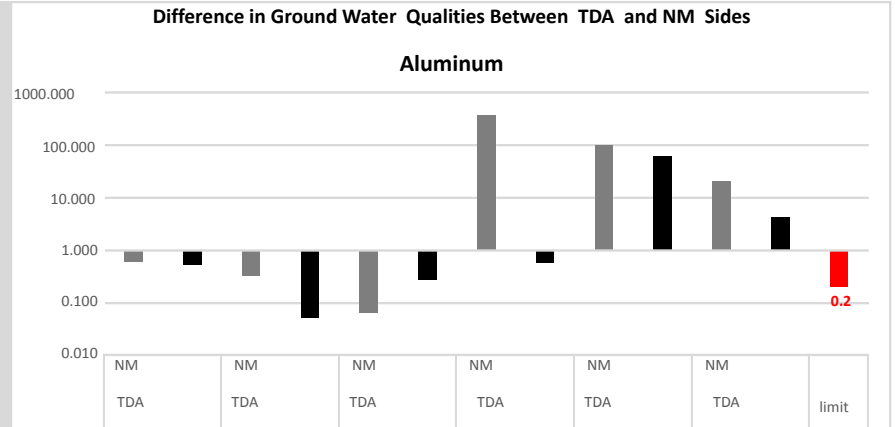
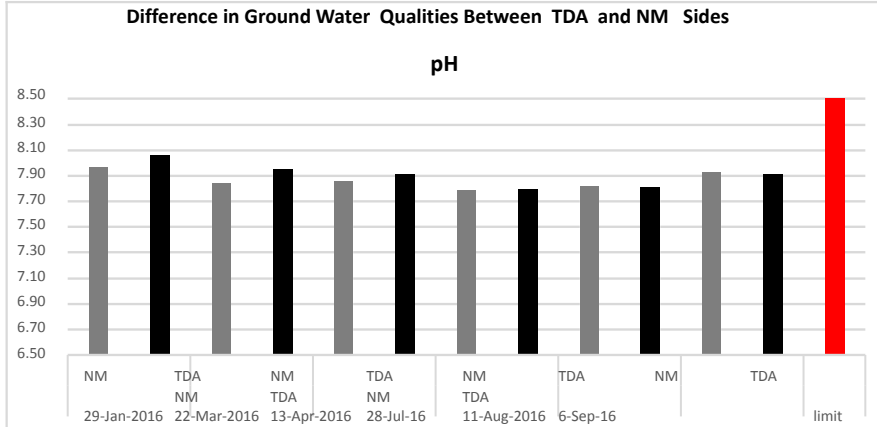
comparison between active, passive, and no ventilation on radon

Boxplot comparison between active, passive, and no ventilation on radon

| Variable | Mean | StDev | N |
|-------------|-------|-------|-----|
| all-active | 22.24 | 17.27 | 522 |
| all-passive | 83.07 | 39.85 | 530 |
| all-capped | 146.5 | 73.79 | 612 |

Phase III

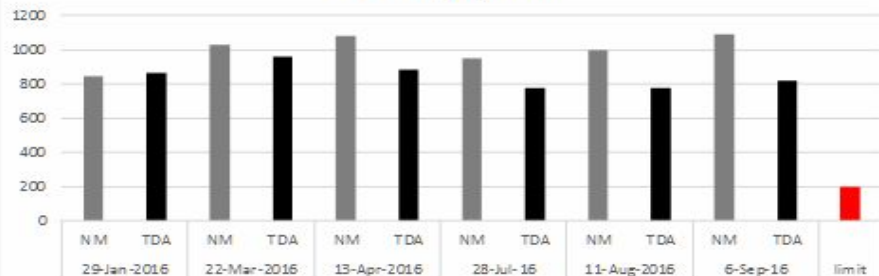
Ground water qualities



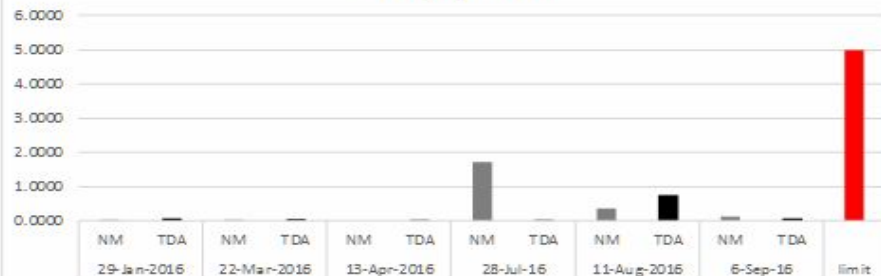
Phase III

Ground water qualities

**Difference in Ground Water Qualities Between TDA and NM Sides
Sodium (Na)-Total**



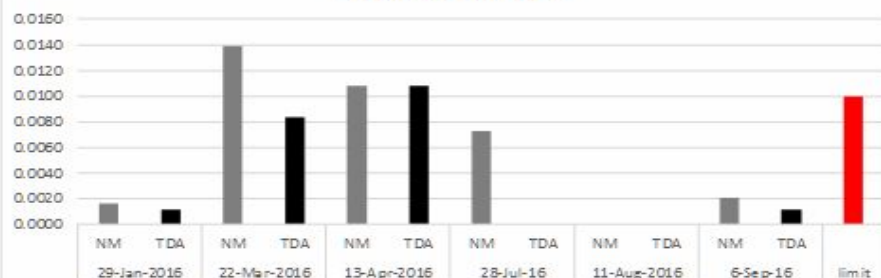
**Difference in Ground Water Qualities Between TDA and NM Sides
Zinc (Zn)-Total**



**Difference in Ground Water Qualities Between TDA and NM Sides
Benzene**

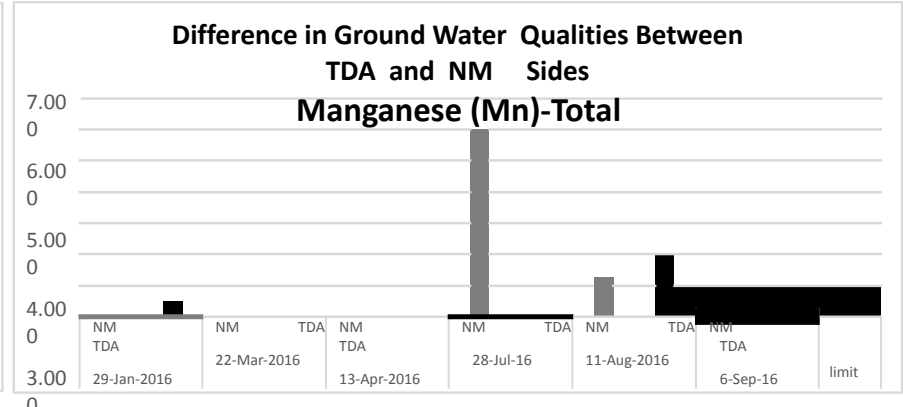
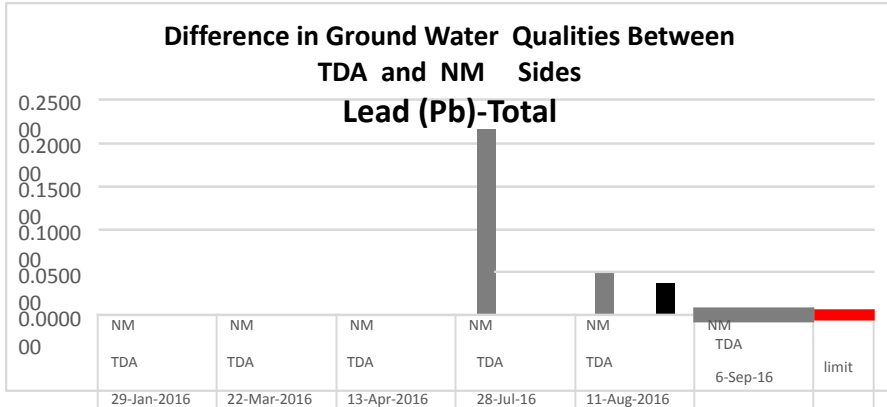
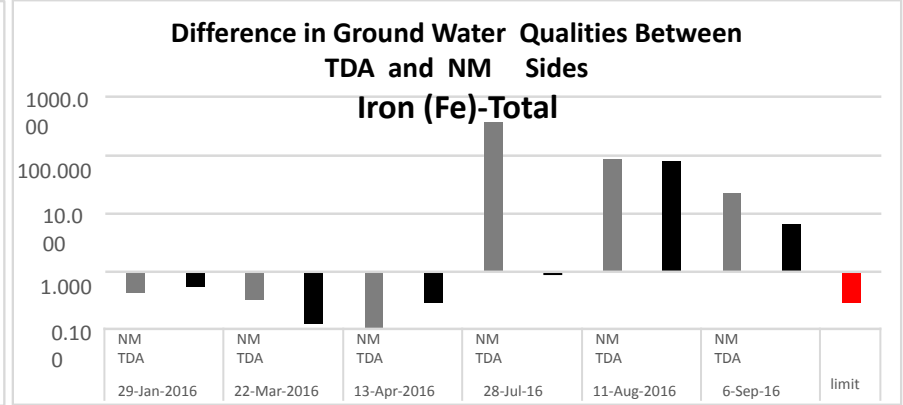
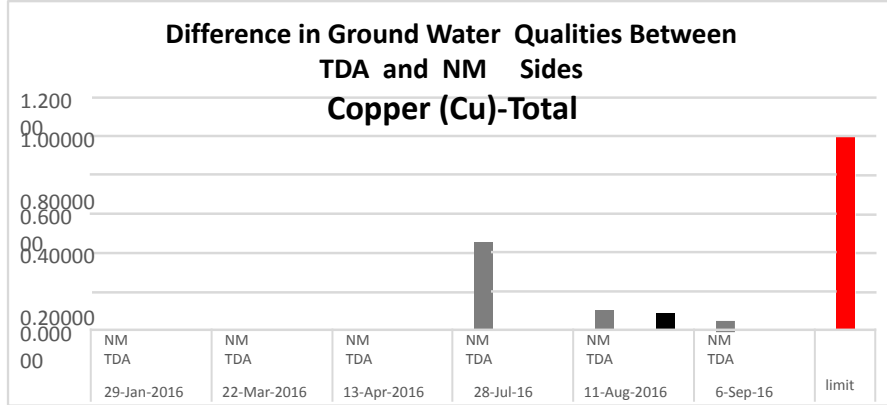


**Difference in Ground Water Qualities Between TDA and NM Sides
Selenium (Se)-Total**



Phase III

Ground water qualities



Phase III

Flash point & Indoor air qualities

Flashpoint Results – TDA Material

>75 Degrees Celsius

Indoor Air Qualities:

Plans to measure: VOC, CO₂, odor, ...etc
no comparative measurements yet
We're assessing measuring systems

| | |
|--|----------|
| Speck 2.0 | \$210.00 |
| <ul style="list-style-type: none">• Includes humidity sensor and improved WiFi range• Detect indoor fine particulate matter (dust, smoke, exhaust, etc.)• Plot trends over time with our free visualization tools• <u>Access your home's data from your smart phone or computer anywhere, anytime</u> | |

• Compare indoor and outdoor* air quality readings on screen

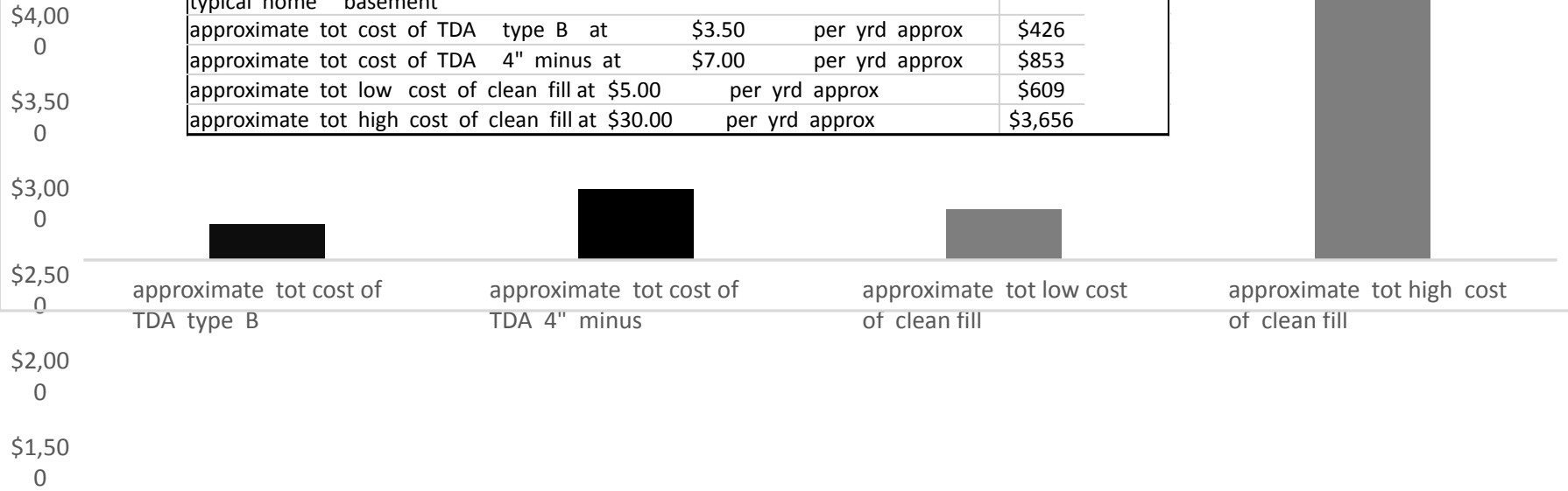
| | |
|--|---|
| Foobot | \$199.00 |
| * tVOC: Volatile Organic Compounds | (Formaldehyde, Benzene, Xylen Toluene e |
| * PM2.5: Particulate Matter | |
| * Temperature & Humidity | |
| * CO ₂ : Carbon Dioxide | |
| * CO: Carbon Monoxide | |
| App compatibility: Apple iOS 7 and above, Android 4 and above | |
| Wifi Connectivity: 2.4Ghz 802.11b/g/n; Open,WEP, WPA,WPA2 personal | |

Phase III

Preliminary Economic Analysis

Approximate total costs for walls backfill and underneath slab 4" base in a typical home basement (excluding delivery costs)

| | | |
|--|---------|------|
| approximate total volume of walls backfill and underneath slab 4" base for a typical home basement | 122 | yrds |
| approximate tot cost of TDA type B at \$3.50 per yrd approx | \$426 | |
| approximate tot cost of TDA 4" minus at \$7.00 per yrd approx | \$853 | |
| approximate tot low cost of clean fill at \$5.00 per yrd approx | \$609 | |
| approximate tot high cost of clean fill at \$30.00 per yrd approx | \$3,656 | |



Phase III

Next Steps

- Continue collecting and analyzing performance data over the next two complete Cycles 2016-2018
- Explore green certification for the material
- Explore improvements

Phase III

Conclusions:

- While small scale (laboratory) tests have established the physical and mechanical properties of TDA, the full scale experiment is demonstrating the performance difference between TDA and natural material when used in basement construction
- With only half a cycle of collecting measurements, no definitive conclusion can yet be made, particularly for some parameters such as: heat losses and moisture migration
- Some other properties such as drainage abilities and lateral pressure are conforming to the laboratory results and common knowledge in literatures.
- Parameters such as: radon levels and ground water qualities appear to favour TDA or at least show no adverse effects on the environment or

Phase III

Conclusions:

- Some construction practices (e.g. placing and compaction) and TDA properties (e.g. size) may need to be adjusted if better performance is targeted (particularly for heat losses)
- **So the question is: should we peruse these adjustments or would that affect the apparent economic advantage?**
- **There is a need to inform building authorities and decision makers- perhaps through White Paper and/or public forums??**