PEG PROTECTION ENGINEERS GROUP

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Case Study: Use of Nomogram Method to Design Low Resistance Ground for a Central Office

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nVent ERICO

Sponsored by: SNC, HUBBELL, BURNDY, nVent ERICO, HARGER, SETsafe, SET fuse

Session 2: *Grounding for GPR and Lightning Remediation*
March 17, 2022

Learning Objectives

Learning objectives for this training:

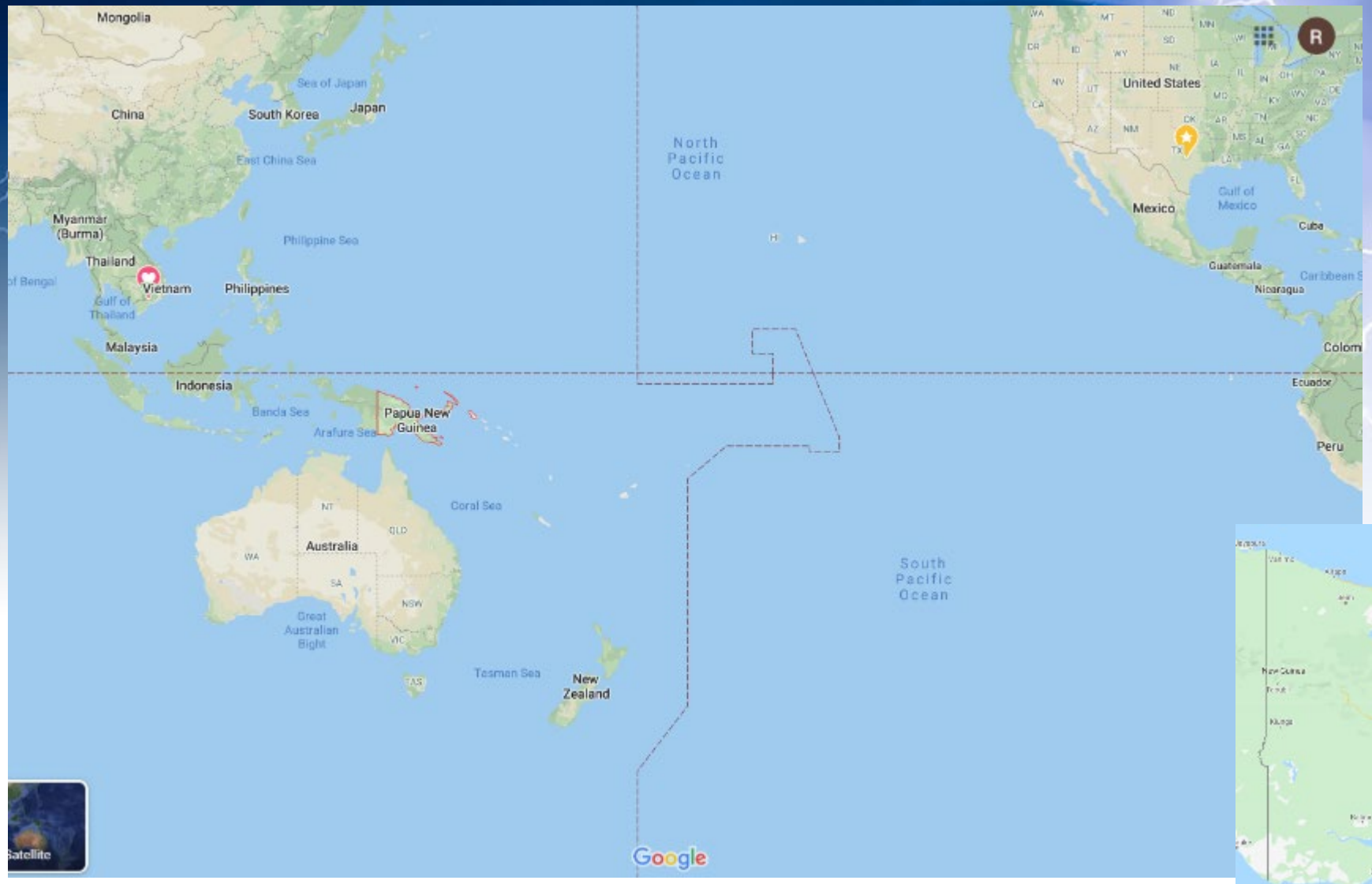
- Design a ground electrode system for a Telecomo site using empirical techniques using formula and Nomogram
- Appreciation the importance of soil resistivity and ground electrode design outcomes

- VODAFONE ATH
- Port Moresby
- Papua New Guinea

NO SOIL RESISTIVITY DATA WAS PROVIDED

- We Visited Site
- There was nowhere really available to do the soil resistivity testing
- It was all concreted

Port Moresby – Papua New Guinea



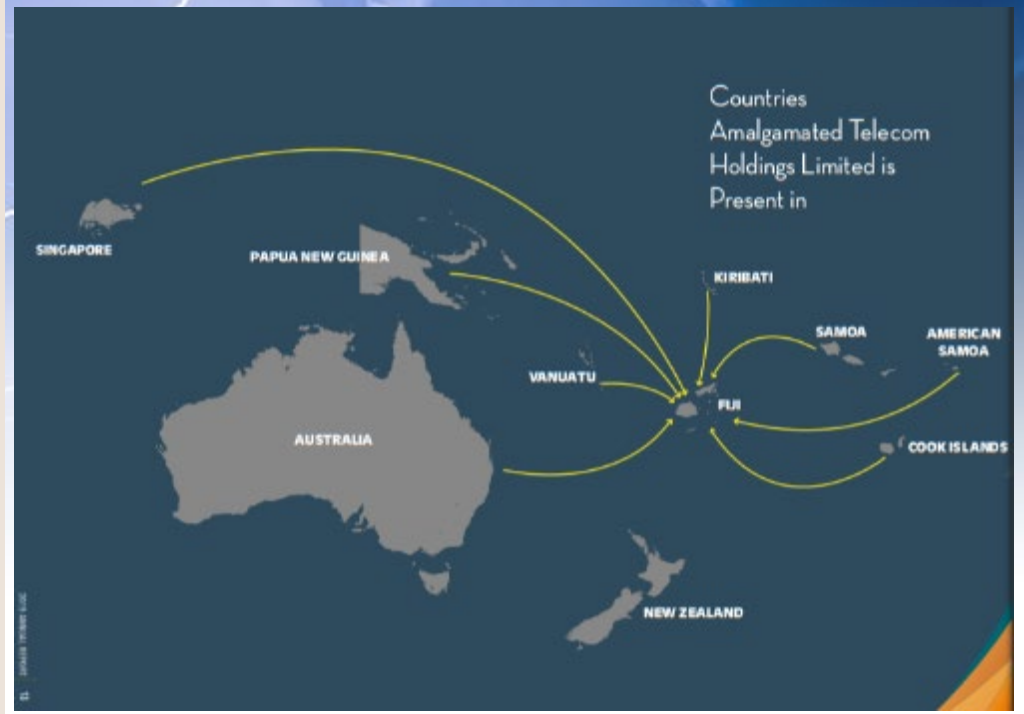
CUSTOMER

Fiji telco ATH buys into Papua New Guinea's ICT market

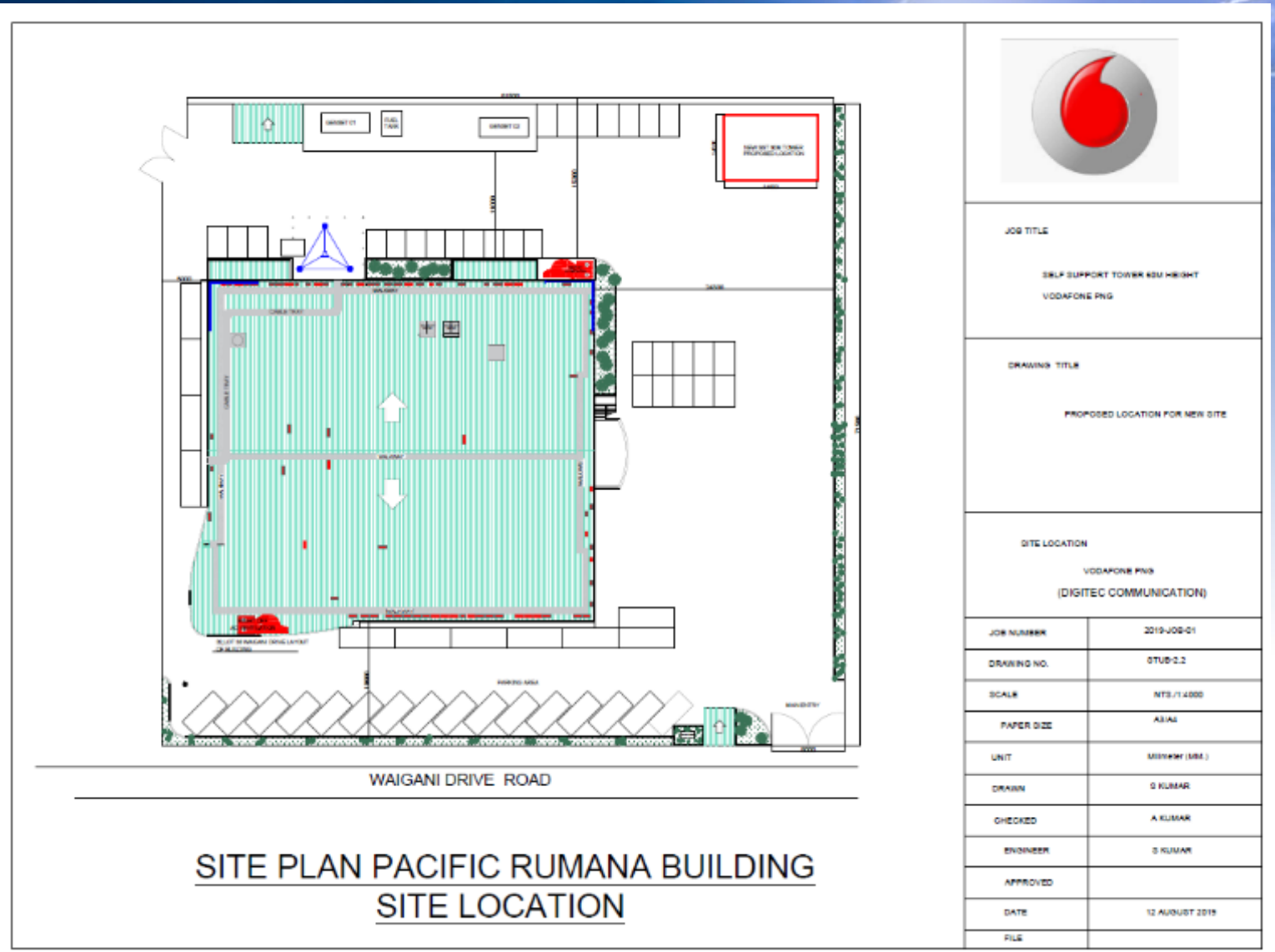
3 Jul 2019 by Kevin McQuillan Leave a Comment

Fiji-based Amalgamated Telecom Holdings has claimed it has struck a deal to acquire 70 per cent shareholding in each of **Digitec Group**, which operates in Papua New Guinea, Singapore and Australia. Analysts say the Fijian company could seek a partnership with an existing mobile operator in PNG.

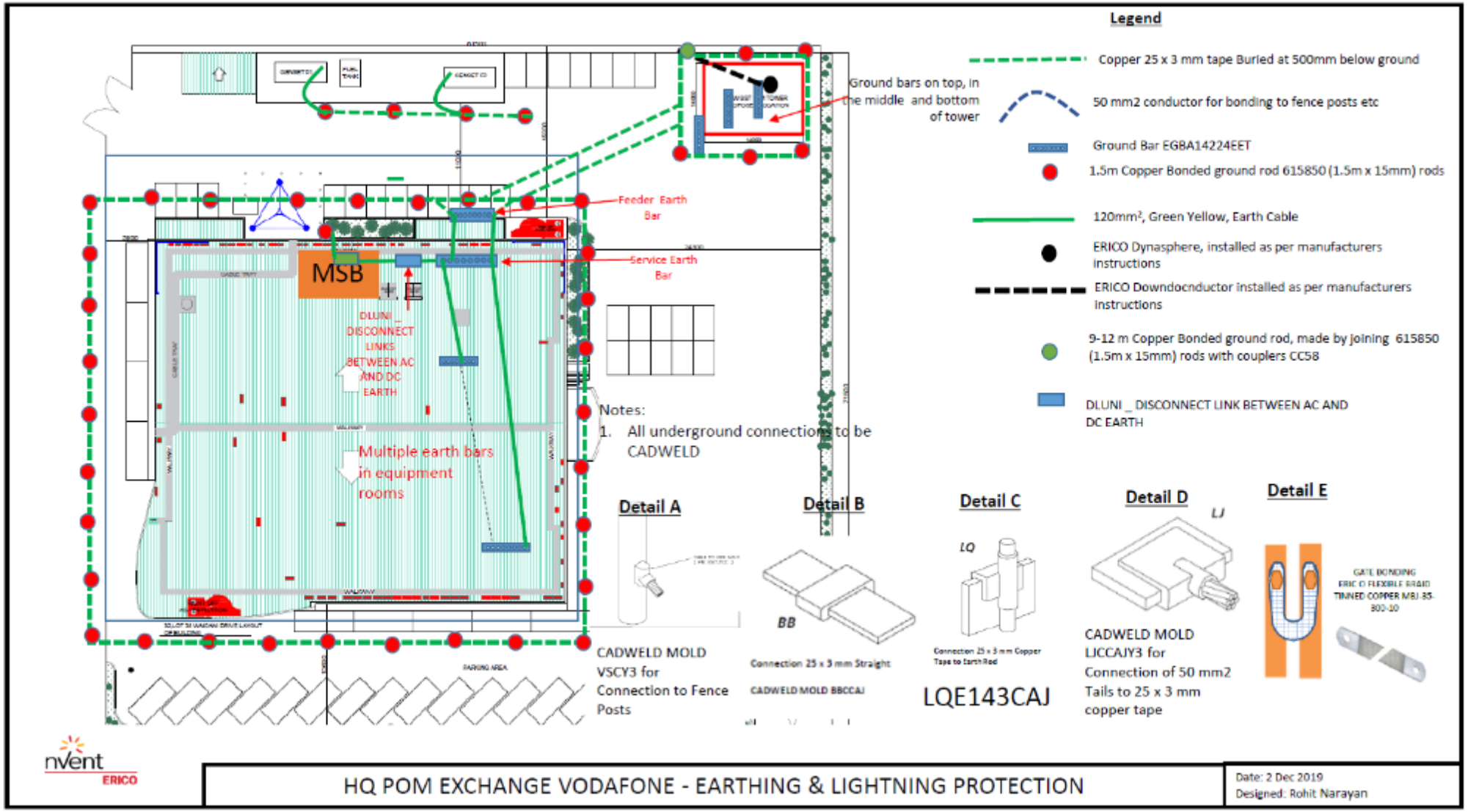
Connection lines around the globe.



Customer Requested a Design of Grounding System

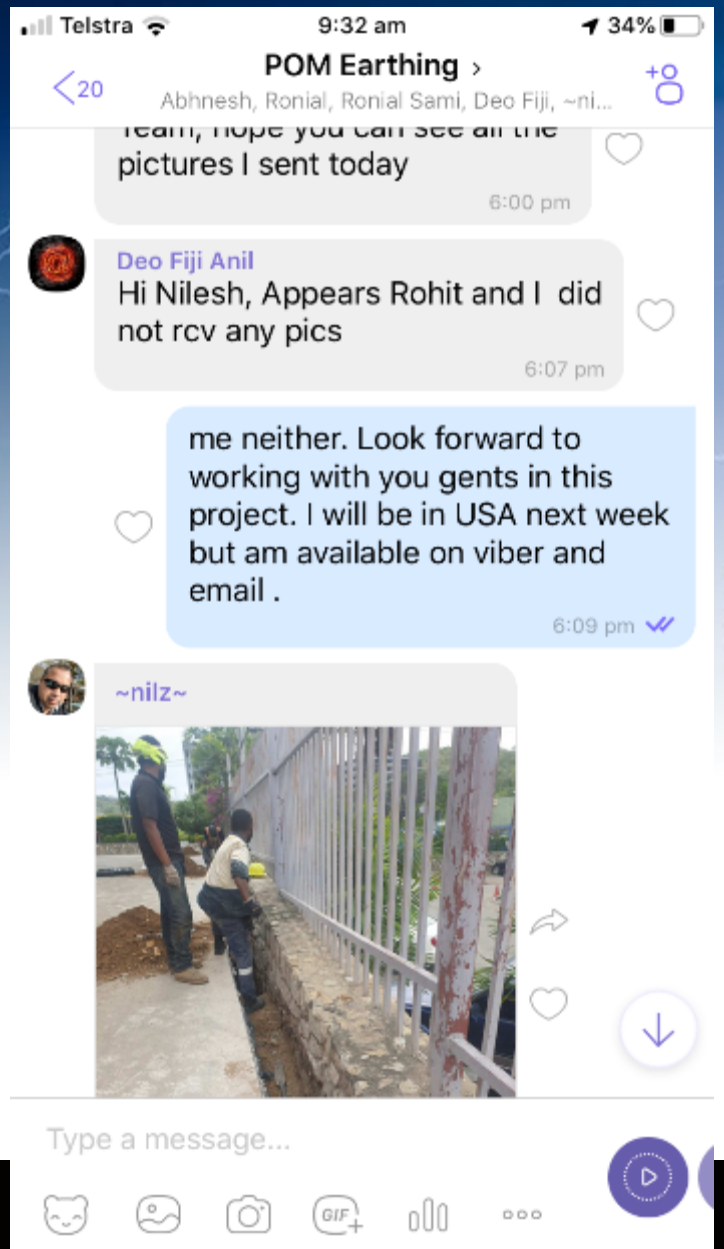


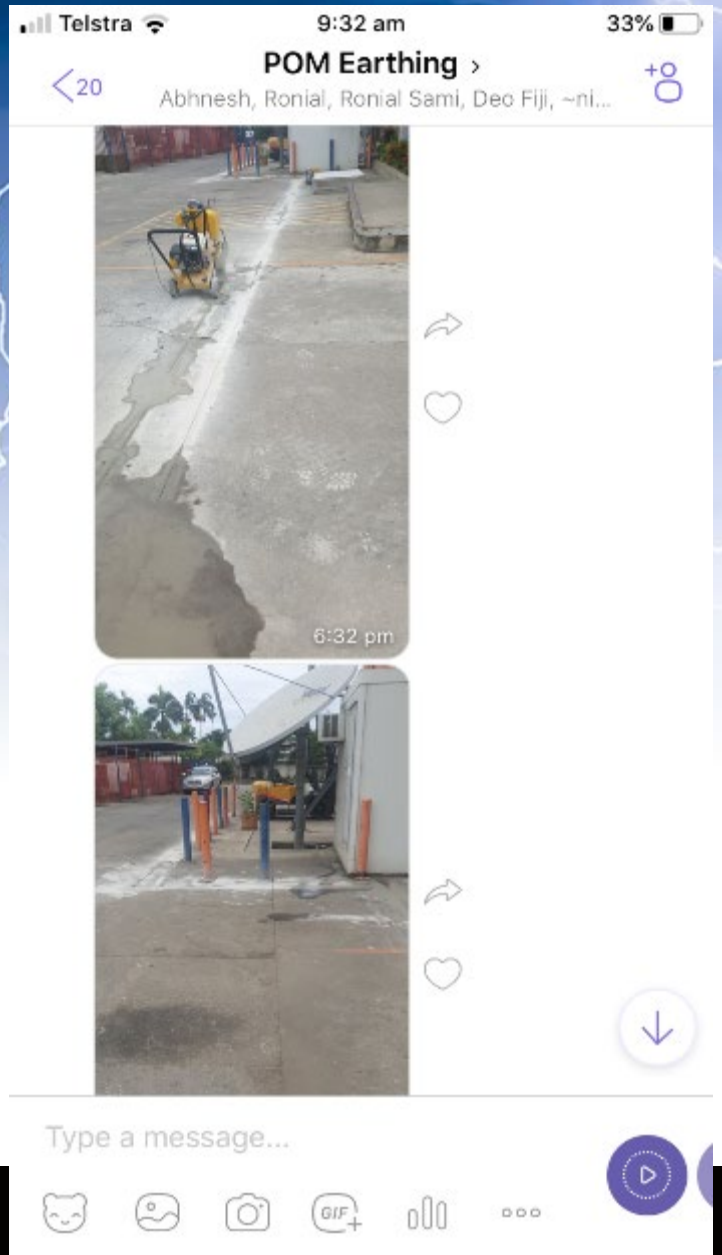
Designed a Concept Without Soil Resistivity Data

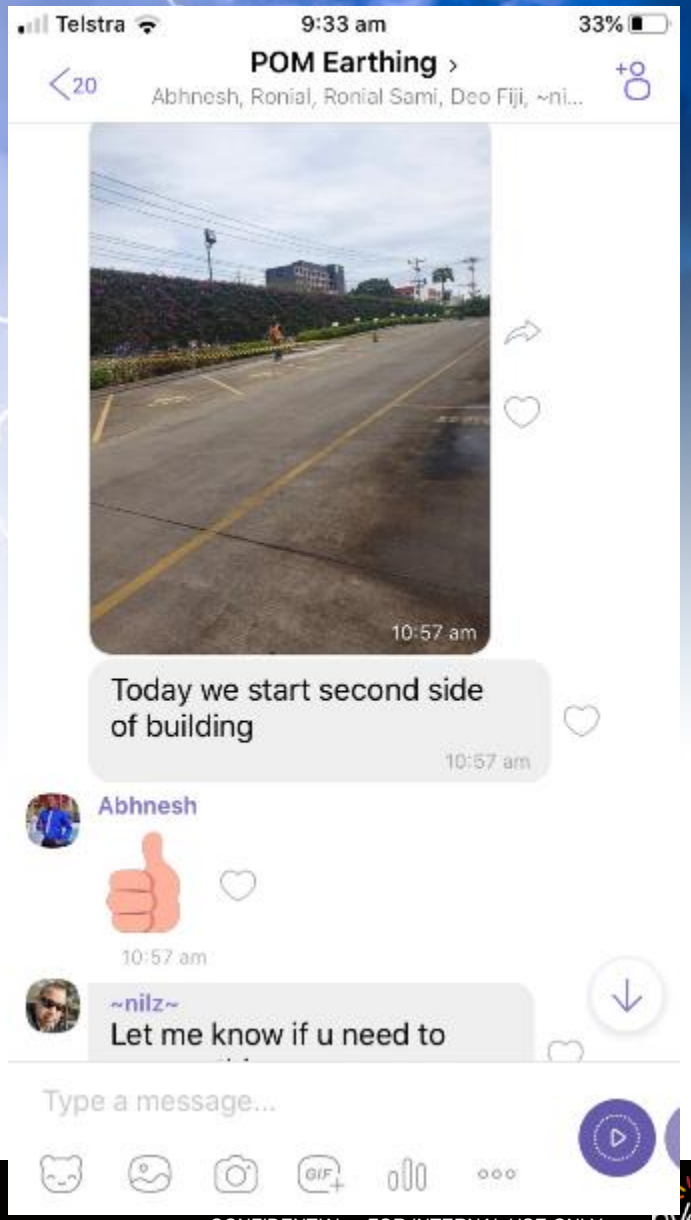


- Customer was not set up to do drilling
- They were not used to driving very deep electrodes
- Design done with lots of 5ft or 1.5m rod (Permitted in Australia)

Much of Communication to Site was Via Social Media – Viber and Watsup







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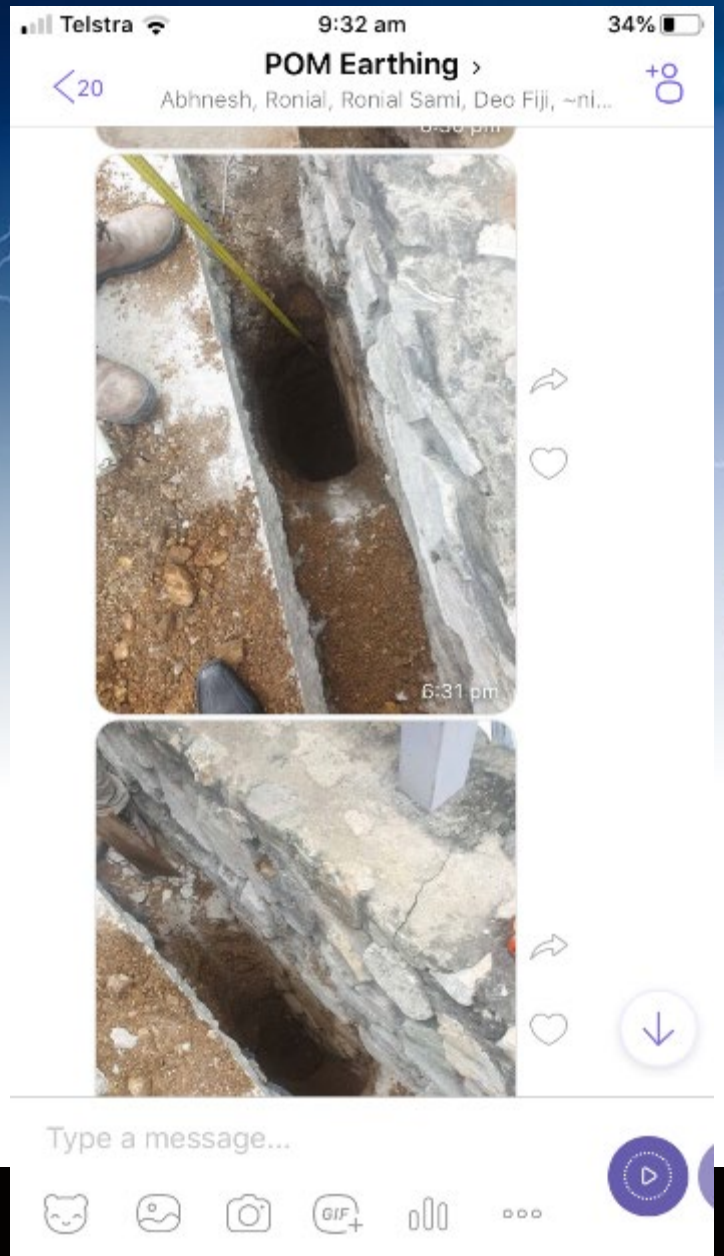
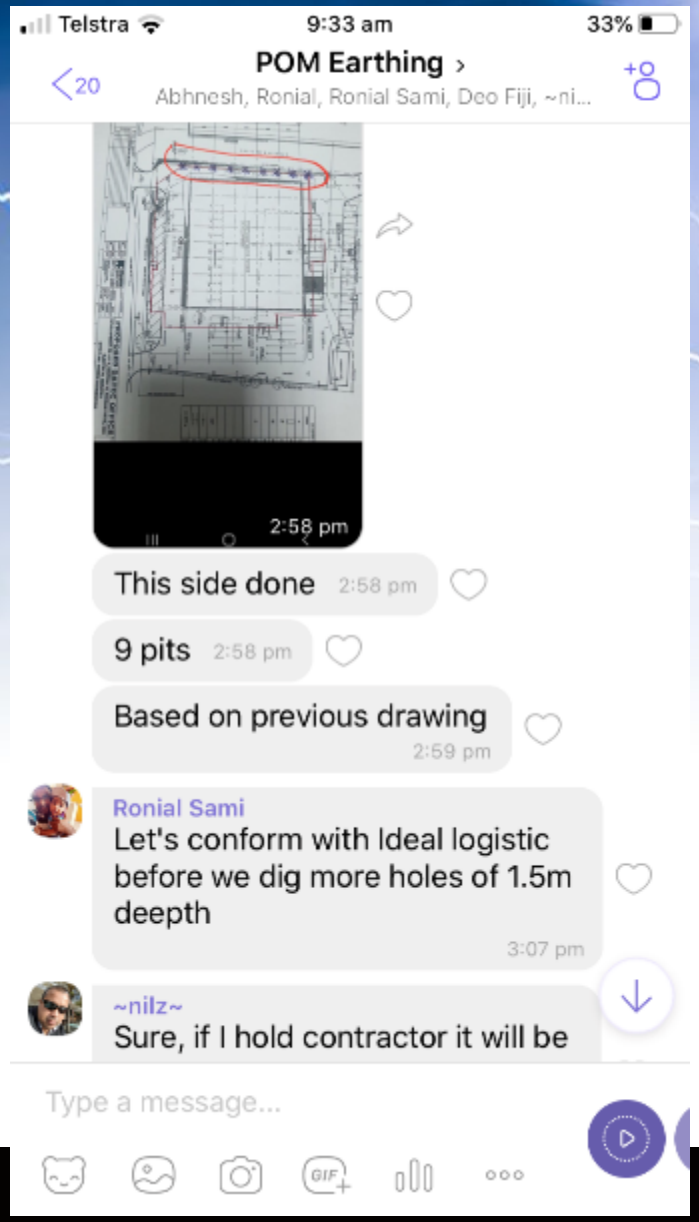
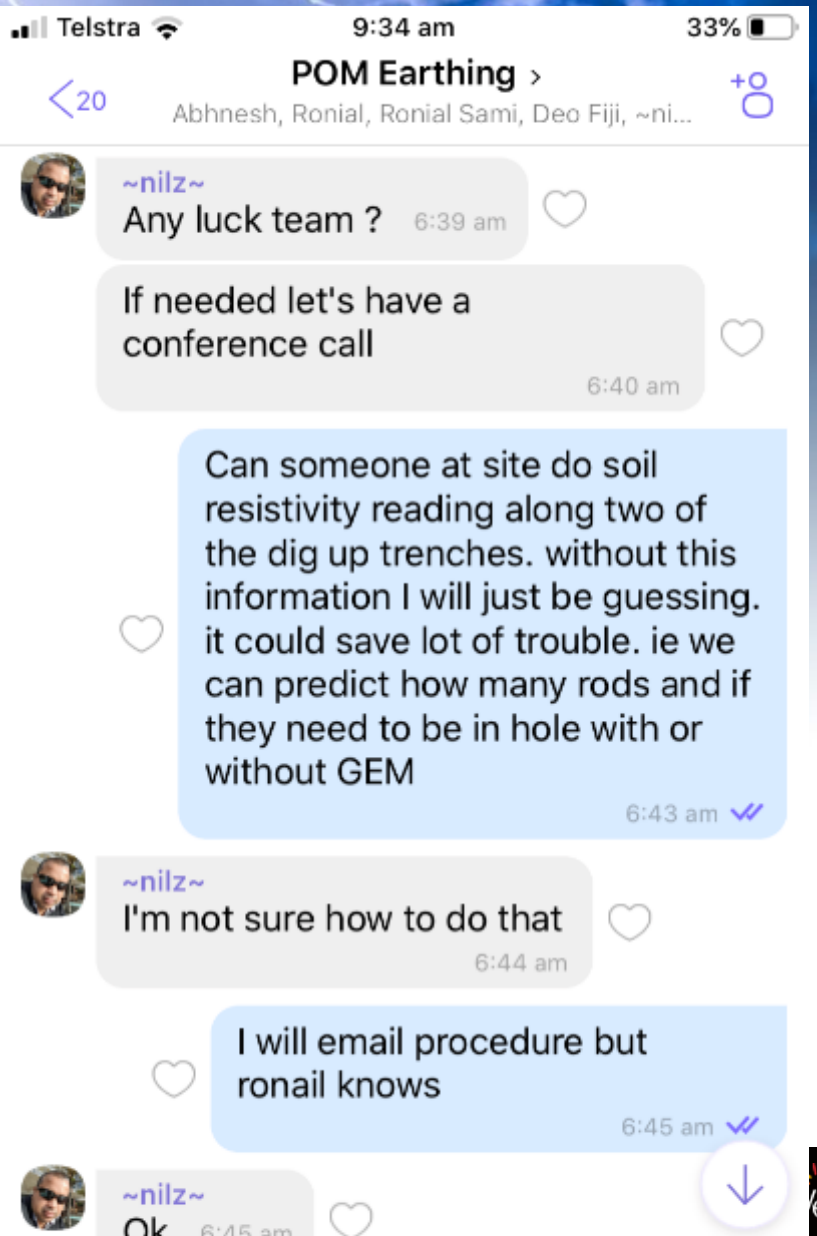






Using the Wenner Array method, four small electrodes (auxiliary probes) are placed in a straight line at intervals of a, to a depth of b. A current is passed through the outer two probes, and the potential voltage is then measured between the two inner probes. A simple Ohm's Law equation determines the resistance. From this information, it is now possible to calculate the resistivity of the local soil. For most practical circumstances, a is twenty times larger than b, where we can then make the assumption that b=0.

Then the Resistivity, ρ is given by:

$$\rho = 2 \Pi a Re$$

where

ρ = *Resistivity of the local soil (Ω-m)*
a = distance between probes (m)
b = depth of probes into the ground (m)
Re = resistance value measured by the tester (Ω)

These values give an average resistivity of the soil to a depth a. It is recommended that a series of readings be taken at different values of a, as well as in a 90" turned axis. It is a good practice to tabulate or plot the results because that gives a good idea of how the resistivity is changing with depth and will give us a better clue on the type of ground electrode to design.

For example, if the resistivity is very high at the top 3 metres but drastically drops after that depth, then one would consider designing using electrodes that are driven or drilled to deeper than 3 metres. Conversely if the resistance does not improve beyond a certain depth, say 2 metres, then horizontal electrodes may be considered in the earth electrode design.

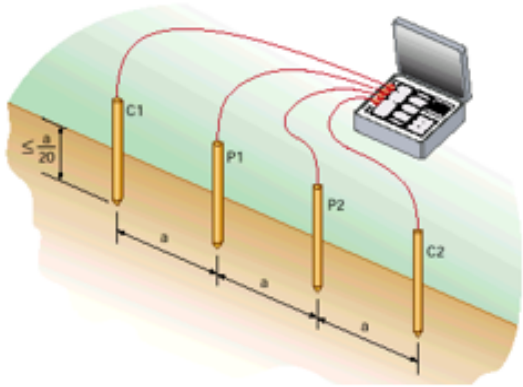


Figure 2 : : Wenner Array (4 Point Method)

Figure 3 shows a typical record sheet for resistivity measurements. It is recommended that for the design of ground electrode, a comprehensive set of results be gathered in the range of 1.5 – 2 metres. The reason for chosing 1.5m spacing is that typical sectional (extendable) earth electrode lengths increase in lengths of 1.5m

*The readings shown in yellow are only required if the resistivity measurement at a=9m is higher than 400 ohm-m

SPACING a, m	Measured Value Rel in Direction 1	Measured Value Re2 in Direction 2 (Perpendicular to Direction 1)	Average of Rel and Re2 = Re	Resistivity p = 2 Π a Re
1.5				
3.0				
4.5				
6.0				
7.5				
9.0				
10.5*				
12.0*				
13.5*				
15*				

Figure 3: Typical Test Record Sheet for Wenner Array Method

Difficulties in Soil Resistivity Measurement

Three common difficulties in obtaining soil resistivity results include:

1) Poor electrical connection between the test probes and the soil. Most modern earth test equipment will pick this condition up as an error and results obtained while the test equipment is showing error are not valid.

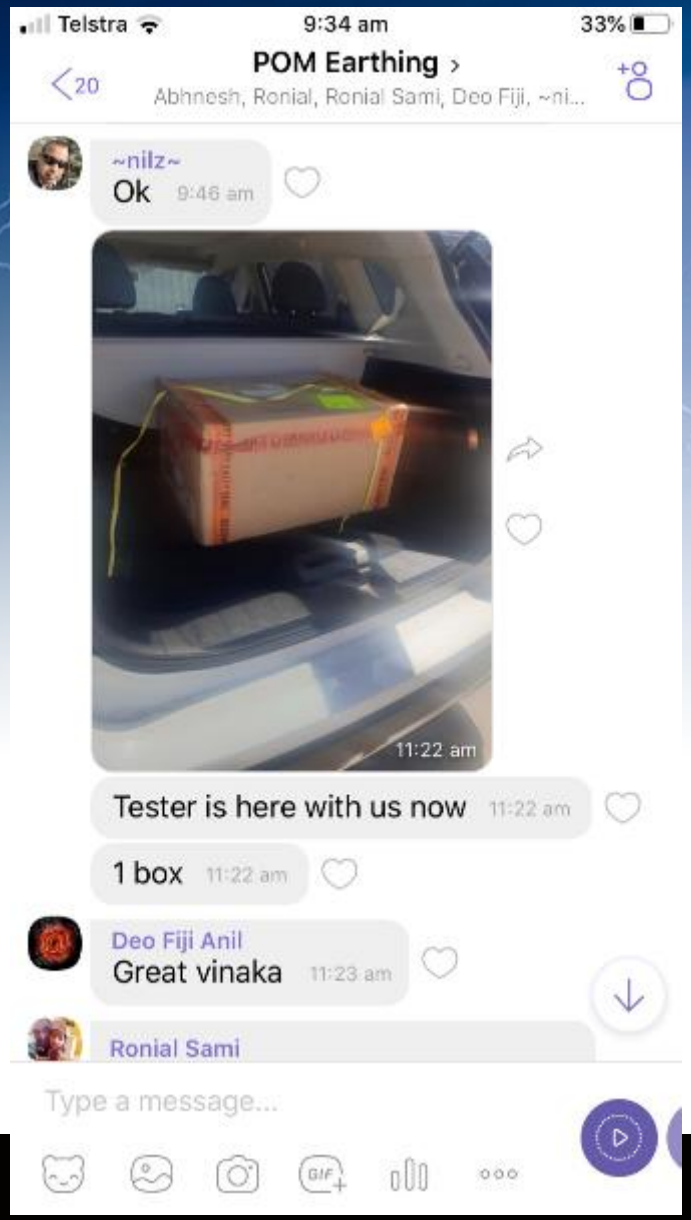
Remedy: If this occurs, the test probes should be driven in a bit deeper. If that does not yield a result without error, then a bottle of water shall be used to wet around each of test probes. If this still does not yield an error free result, salt mixed with a bottle of water may be used to wet the area around the test probes.

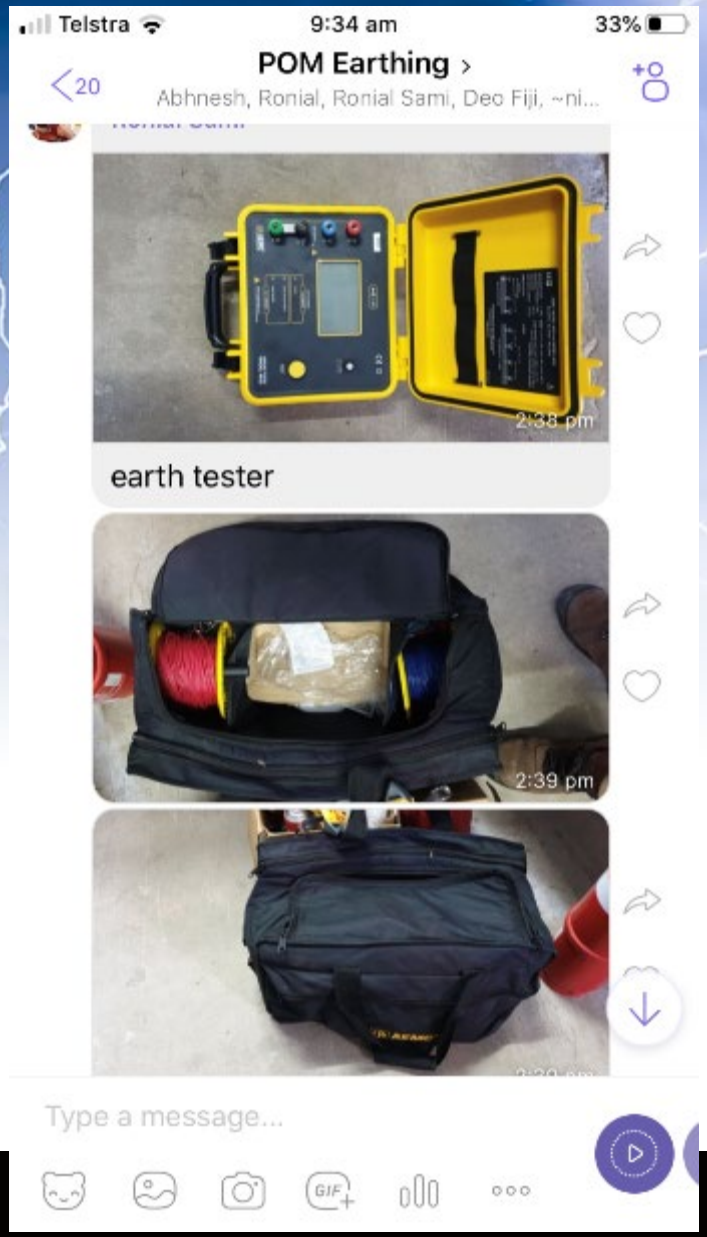
2) Test Equipment Limitation

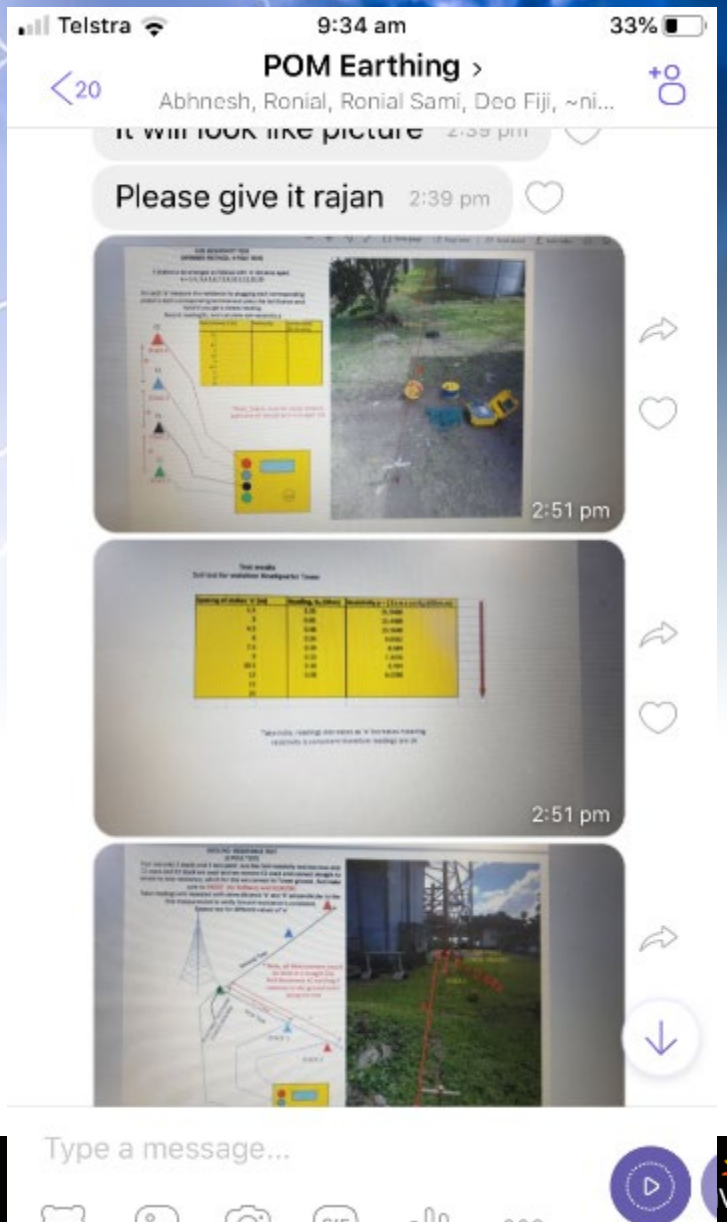
The test equipment produces a certain current to enable the tests. In sites with extremely high soil resistivity and especially at large probe spacing a, the equipment may not have adequate current source to obtain a measurement.

Remedy: Abort Test and note down reasons or use a specialist high current equipment to carry out the test????? Is this feasible???

Test Equipment Arrived in Town – Site Engineer Figured Out Testing







Telstra 9:35 am 33%

20 POM Earthing › Abhnesh, Ronial, Ronial Sami, Deo Fiji, ~ni...

Here is measurement 6:22 pm

Please help check 6:39 pm

Ronial will be on site on 20th 6:39 pm

To continue from here 6:39 pm

19 February 2020

i want 4 pole resistivity test done . not resistance. as per email instructions i sent 12:21 am

~nilz~

@Rohit Narayan , Ronial will help do that on Thursday. The contractors are continuing work in cutting the cement around the building as per marked area. They will not dig any more pits until you confirm. 7:06 am

good plan 7:06 am

Type a message...

Telstra 9:35 am 33%

20 POM Earthing › Abhnesh, Ronial, Ronial Sami, Deo Fiji, ~ni...

at 9m

at 10.5m

at 12m

Type a message...

Telstra 9:36 am 33%

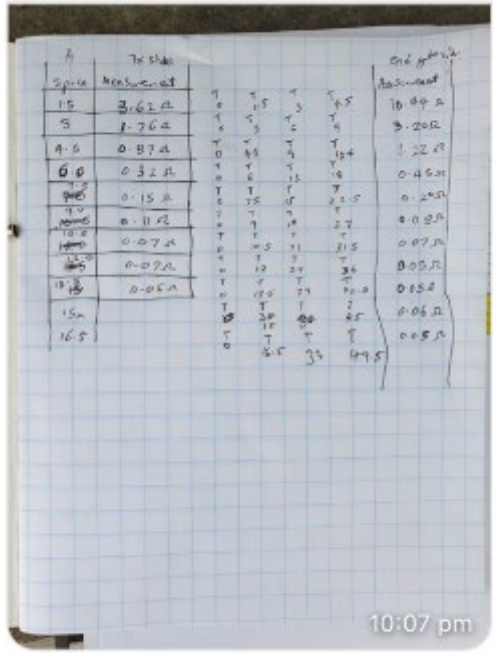
20 POM Earthing › Abhnesh, Ronial, Ronial Sami, Deo Fiji, ~ni...

Good result 8:34 pm

I will have to analyse a bit but yes great results. should not need GEM but wait for my calculations 9:26 pm

will work on this soon 9:37 pm

Ronial Sami



Target Resistance Value

TABLE 4.1

MAXIMUM RESISTANCE TO EARTH OF SERVICE EARTHING ELECTRODE SYSTEM

Telecommunications facility	Resistance of service earth, Ω
Major multifunctional installation	0.5
Major urban or provincial exchange	1.0
Small exchange (Note 1)	2.0
Radio transmission site (Note 1)	2.0
Cable transmission site (Note 1)	5.0
Other facilities (including mobile base stations)	5.0

NOTES:

1 Where the electricity supply is via a single phase HV/LV transformer in a rural environment, it is possible that an active to earth fault may not be

CALCULATIONS STEP 1

RESISTIVITY DATA				
a	RE TX Side	RE End Gate Side	Average Re	Resistivity
1.5	3.62	10.44	7.03	66.3
3	1.76	3.2	2.48	46.8
4.5	0.87	1.22	1.045	29.6
6	0.32	0.45	0.385	14.5
7.5	0.15	0.2	0.175	8.3
9	0.11	0.08	0.095	5.4
10.5	0.07	0.07	0.07	4.6
12	0.06	0.05	0.055	4.1
13.5		0.05	0.05	4.2

The **Earth Resistance (R_g)** of a single spike, of diameter (d) and driven length (L) driven vertically into the soil of resistivity (ρ), can be calculated as follows:

$$R_g = \frac{\rho}{2\pi L}\left[\ln\left(\frac{8L}{d}\right) - 1\right]$$

where: ρ *Soil Resistivity in Ωm*
L *Buried Length of the electrode in m*
d *Diameter of the electrode in m*

Examples

(a) 20mm rod of 3m length and Soil resistivity 50 Ω-m ..... R=16.1Ω
(b) 25mm rod of 2m length and Soil resistivity 30 Ω-m ..... R=13.0Ω

CALCULATIONS FOR RESITANCE

SINGLE VERTICAL ELECTRODE

APARRENT RESISTIVITY ohm-m	66
ELECTRODE DEPTH in m L	1.5
ELECTRODE DIAMETER m	0.015
Resistance	39.82848981

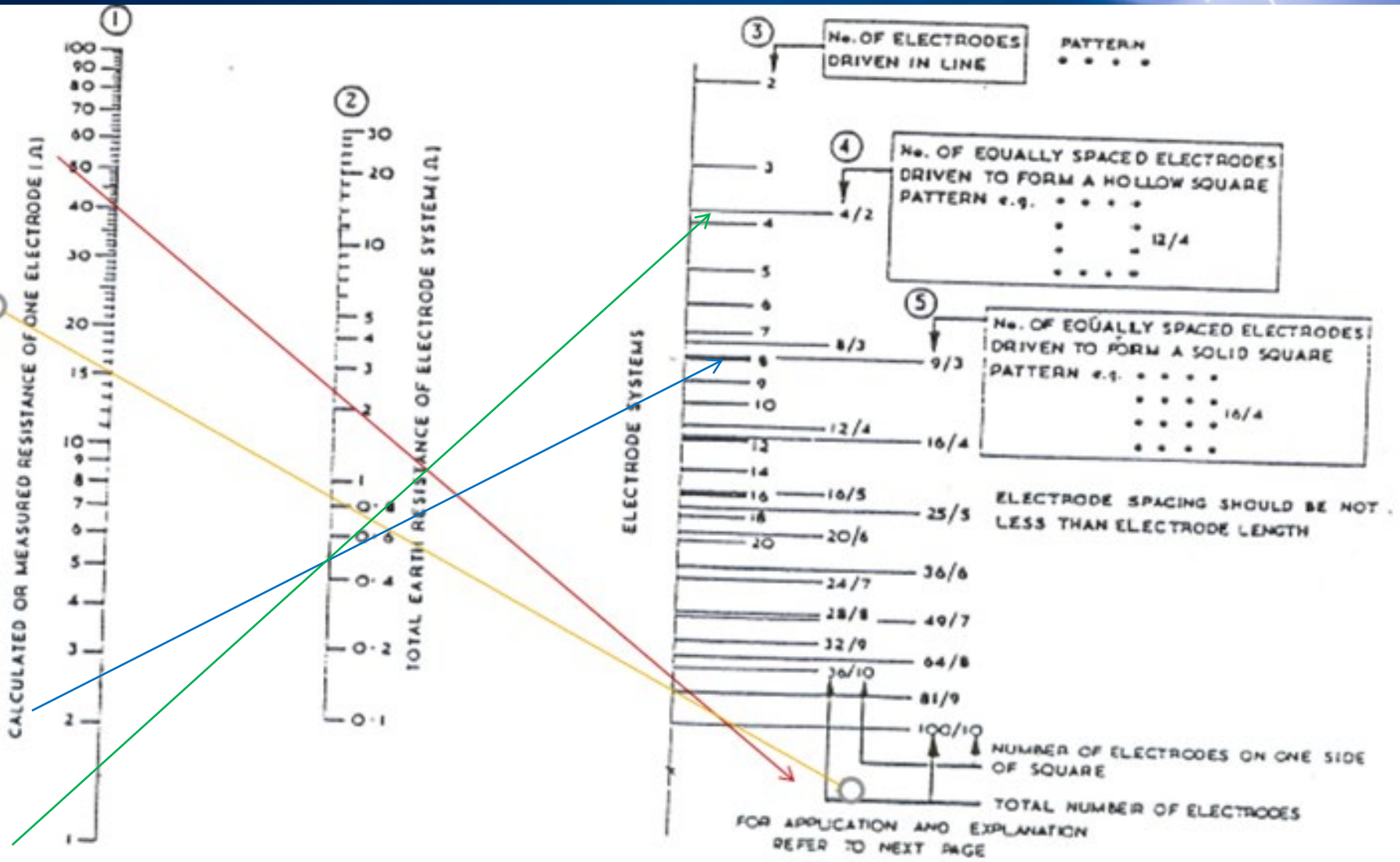
SINGLE VERTICAL ELECTRODE

APARRENT RESISTIVITY ohm-m	46
ELECTRODE DEPTH in m L	3
ELECTRODE DIAMETER m	0.015
Resistance	15.57202281

SINGLE VERTICAL ELECTRODE	
APARRENT RESISTIVITY ohm-m	14.5
ELECTRODE DEPTH in m L	6
ELECTRODE DIAMETER m	0.015
Resistance	2.721022778

SINGLE VERTICAL ELECTRODE	
APARRENT RESISTIVITY ohm-m	8.3
ELECTRODE DEPTH in m L	7.5
ELECTRODE DIAMETER m	0.015
Resistance	1.285363312

CALCULATIONS STEP 2



GROUND RESISTANCE OF MULTIPLE ELECTRODE SYSTEMS

Results for Approx 40+ Rods x 1.5 m = 2.3 ohms
Results for Approx 40 Rods x 3m = 0.8 ohms
Results for Approx 6m Rods x 9m = 0.5 ohms
Results for Approx 7.5m Rods x 4m = 0.5 ohms

Telstra 9:36 am 33%

20 POM Earthing › Abhnesh, Ronial, Ronial Sami, Deo Fiji, ~ni...

great work Ronial. This will really make predictions easy
10:10 pm

I have sent email with Calculations and suggestion. Not as straightforward as you may think
11:26 pm

21 February 2020

~nilz~
So in summary, please advise what is the change from existing scope ?
5:09 am

Please look at my email and advise which option you like to take a b c or d. after that i can advise change in scope. For Lae we must do this test first
6:16 am

~nilz~
Ok, Ronial to advise today. I'm

Type a message...

Telstra 9:37 am 32%

20 POM Earthing › Abhnesh, Ronial, Ronial Sami, Deo Fiji, ~ni...

Ronial Sami
We put 4 rods so. 1.5m x 4rods coupled. 6m drive.
6:19 pm

Last distance 53m. Mid distance at 0.62of 53m
6:20 pm

We will try to put join one more and drive to 7.5m tomorrow.
6:20 pm

Deo Fiji Anil
Rohit what you suggest from.the readings Ron provided
6:23 pm

Type a message...

Telstra 9:38 am 32%

20 POM Earthing › Abhnesh, Ronial, Ronial Sami, Deo Fiji, ~ni...

10:42 am

i have sent email 10:46 am

Ronial Sami
We managed to go 7.5 deep. Later today we try other 3 corners ones cement is cut and 1.5m hole is dug up
11:39 am

Abhnesh
We arranging couplers frm fiji
12:02 pm
1

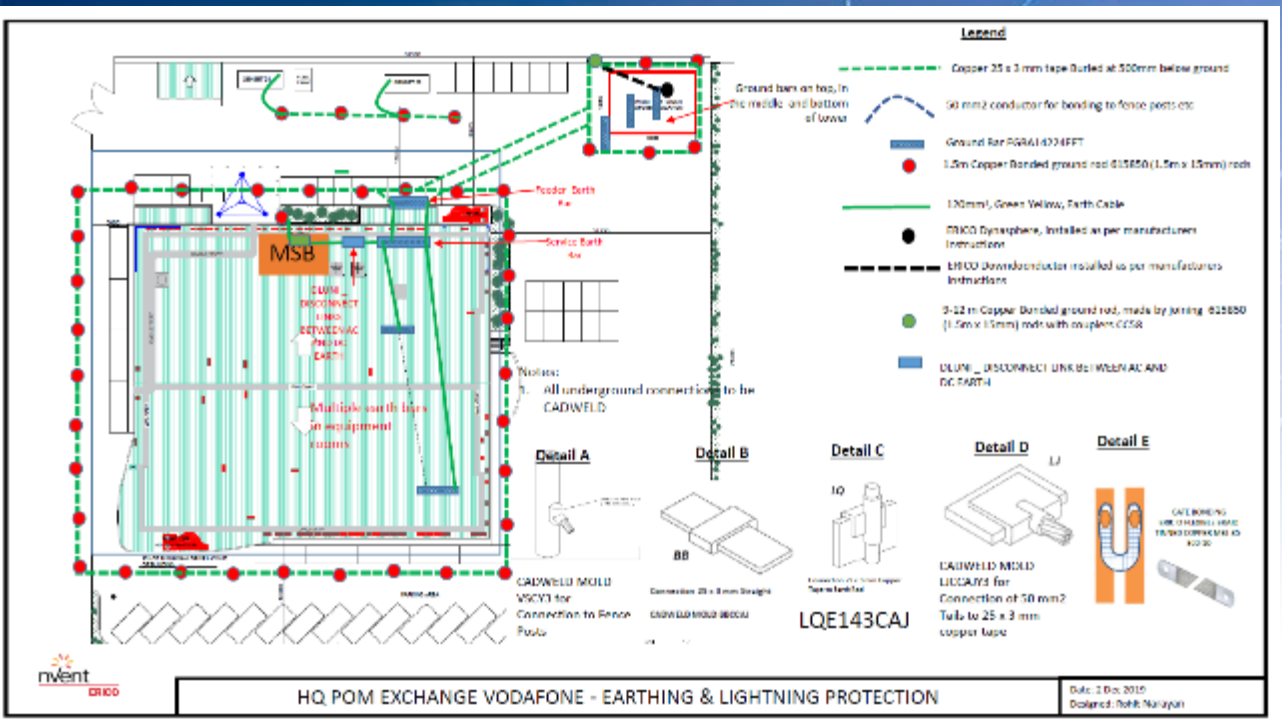
Deo Fiji Anil
Thanks Abhinesh. I will replace you on Monday
12:10 pm

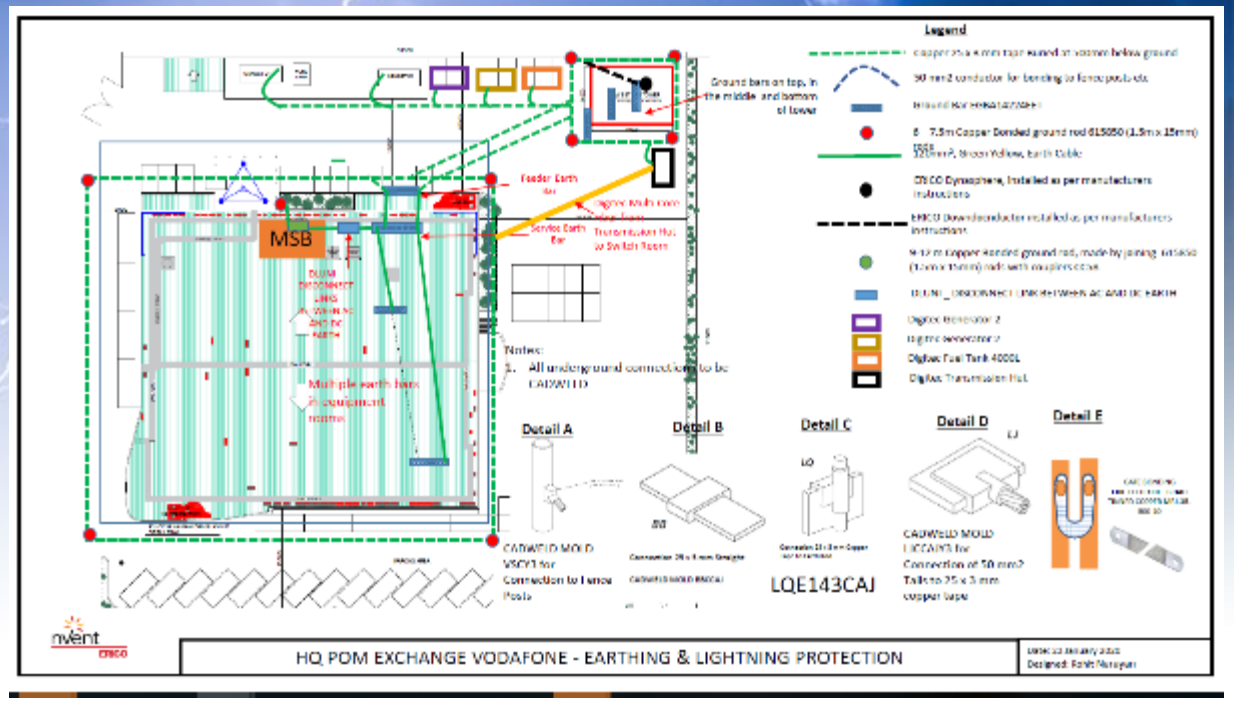
Ronial Sami
We have managed to place another corner with 7.5m deep rod
1:46 pm

We will start trying another 3rd corner with rod

Type a message...

Design Change – Iteration at Site Plus Soil Resistivity Calc. Use of Social Media





- 40 electrodes by 1m will give 2.3 Ohms

- 4 electrodes by 7.5m will give 0.5 Ohms

CONCLUSION

- At this site 4 ground rods at 7.5 m will give 0.5 ohms resistance
- The customer may opt to install more electrodes in between and around tower
- The end result will be quite different to initial design
- Nomogram is Extremely Powerful tool
- Full information on this site with Surge Protection, Indoor grounding, System 3000 and sull implementation of ERICO 6 Point Plan will be provided is a future webinar . Still Being Constructed