Electrical Earthing (or Grounding) and GEE slab earthing

Druk-Care Engineering strives to provide the best electrical earthing technology that is safe, durable, and maintenance free for all houses, institutions, electrical and electronic facilities and infrastructure in the country. It would therefore be useful if our customers read and understand the following.

(A) What is an earthing (or grounding) installation and why is it essential?
(B) Why you should NOT use salt based pipe/plate earthing installations!
(C) What is GEE slab earthing and why is it the better earthing option?
(D) Earthing connectors and backfill soil
(E) Other important notes/recommendations for GEE earthing slab installation
(F) GEE earthing product price list and Terms for sale

(A) What is an earthing (or grounding) installation and why is it essential?

Earthing (or Grounding) is an electrical installation designed to safely divert any unintentional hazardous currents/voltages into the earth/ground. It also provides a common reference voltage point in an electrical circuit/system. Because it plays a vital role, it is a mandatory installation by regulation for all houses, power, telecom, IT systems, other facilities, etc. An *Earthing* installation has the following three main functions:

1. *Safety of lives*

Electrical faults occur occasionally and even small fault/leakage currents can be hazardous (and even fatal). Earthing installations must maintain the Step and Touch voltages within safe limits. Power utility O&M personnel that handle electrical infrastructure regularly and the general public (especially those that are not electricity literate) are more prone to electrical hazards.

2. *Protection of facilities, houses, machines and equipment*

A good Earthing installation is essential for fixing the reference voltage at 0V (or very close to 0V at all times). Electrical/electronic protection devices will not function properly without proper earthing and hazards (including fire) may occur. For example, without low resistance earthing installations, MCBs will not open (i.e. to isolate faults) in the event of an accidental Live-Earth short circuits. Lightning Arrestors and Surge Arrestors will not function properly without a good and reliable earthing. Consequently, expensive electrical equipment (e.g. transformers) and communication equipment can be damaged due to lightning and switching power surges. Electronic products (computers, modems, routers, etc) are also occasionally damaged due to power surges.

3. *Proper operation of electrical, telecommunication, and IT equipment*

Power – All electrical equipment need to be properly *earthed* for proper operations. E.g. With poor earthing, electrical transformer neutral voltage will not be fixed at 0V (but will fluctuate with unbalanced loads) and will subject consumer loads to large voltage variations (especially during faults). Consequently, consumer electronics can malfunction or can be damaged or life shortened. A reliable transformer earthing is therefore imperative in order to improve the quality of electricity supply.
Telecom and IT – A good *earthing* is necessary to establish a common reference voltage for all the interconnected electronic devices (computers, printers, telefaxes, photocopiers, modems, routers, etc).

Mismatches in reference voltages existing between interconnected devices will result in ground loops that can result in ICT hardware malfunction and corruption of data (E.g. computer crashes and network malfunctions). Much time, money and productivity can be lost in troubleshooting and fixing computer system crashes and malfunctions. Banks and other similar institutions that are heavily dependent on ICT are especially vulnerable.

(B) Why you should NOT use salt based earthing installations!

Most electricians, engineers, and builders with some years of practical experience know that the conventional salt based pipe or plate earthing only provide a temporary utility at best. Firstly, salt accelerates the corrosion of the metal electrode (i.e. pipe, plate, rod) and the joints. The by-products of corrosion deposited on the electrode surface greatly increase the earthing resistance making the installation useless within the first few years (even copper electrodes!). It is therefore **not durable**. Secondly, salt requires water to dissolve and form the required electrolyte to enable the earthing installation to function effectively. Therefore the earthing resistance is generally lower during wet seasons and higher during dry seasons (unless watered regularly). Salt also dissolves and depletes rapidly during rainy seasons (especially in porous soils). Salt based earthing installations therefore provide greatly fluctuating earthing resistances and are thus **not reliable**. It must also be mentioned that the soil resistivity in Bhutan (and Himalayan region) is generally high and installing just the electrode (i.e. pipe, plate or rod) without the use of salt will **not** provide the required low earthing resistance (unless several sets are installed in parallel). *Inspite of years of empirical evidences corroborating the above facts, it is unfortunate that hundreds of conventional salt based earthing installations continue to be installed every year (due to lack of awareness and information).*

The picture (at left) shows the corroded earthing plate dug up from a defunct salt based earthing installation.
Such installations provide a short term utility and problems are generally realized only after the occurrence of electrical hazards (some of which are fatal!).
In some cases, the earthing conductor (usually bare and exposed) is dangerously charged (due to faulty wiring, tampering, insulation deterioration, etc) when the electrode is defunct.
It is also not feasible for electricity utilities to monitor thousands of such earthing installations.

In summary, the following are some of the main problems posed by salt based pipe/plate/rod earthing installation:

(a) people and property are exposed to greater risks of electrical hazards,
(b) electrical transformers and switch gear face greater likelihood of failure and/or malfunction,
(c) poor/bad earthing will contribute to deteriorating power supply quality,
(d) computer networks (digital communication) will not function reliably without an effective earthing (and especially when ground loops exist).

If you have read and understood (A) and (B) above, you would definitely want a safer, a very durable, and maintenance-free option as detailed below in (C).

(C) What is GEE (Ground & Electrode Enhancement) earthing and why is it the better earthing option?

In order to overcome the problems (i.e. short life, poor reliability, need for regular monitoring and maintenance) associated with salt based earthing installations, GEE earthing slabs were developed and fine tuned over several years. GEE earthing slabs are prefabricated electrically conductive concrete slabs that can be chain linked into various lengths according to the: site soil conditions; grounding application; and space availability. Unlike the conventional salt-charcoal pipe or plate earthing, GEE slab earthing provide a very durable, reliable, and maintenance-free earthing utility.

Specifications (for 1 GEE slab)

a) Length x Breadth = 5 ft x 1 ft (i.e. including 6 inches GI flat protrusion from each end)
b) Thickness ~ 1.5 inches
c) Weight ~30 kgs +/- 1 kg
d) One 12 mm hole provided at each end of GI flat for bolting

Note: The number of GEE slabs required per installation depends on the site soil conditions and the purpose (i.e. earthing application). For residential house earthing, a minimum of 6 GEE slabs (i.e. installed in accordance to manufacturer's recommendations) has generally been adequate for most sites that are **not** sandy or rocky. However, installing more GEE slabs per installation will provide better earthing and will also provide the safety margin against variations in soil resistivity due to variations in soil moisture content, and soil temperature.

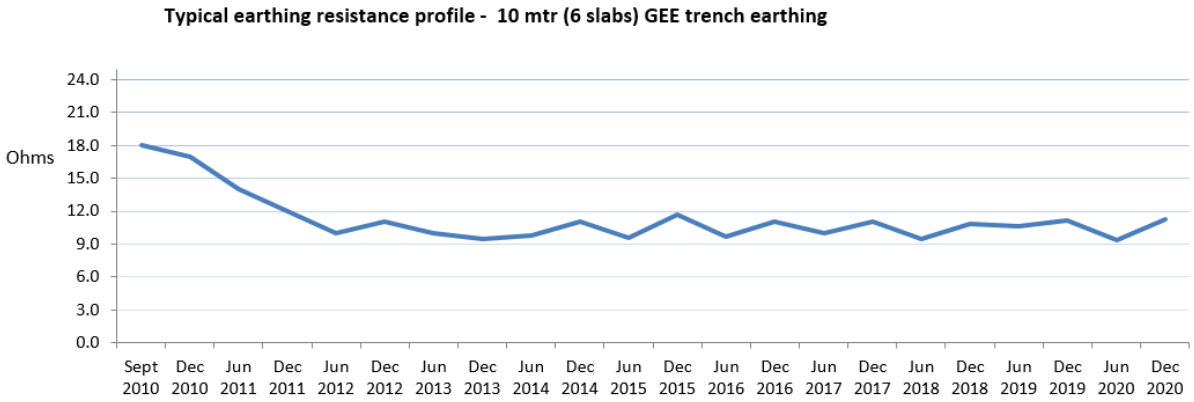
GEE slab earthing is designed to facilitate convenient and rapid installation. The basic idea is to dig a trench and bury the interconnected GEE slabs in low resistivity backfill soil (Eg. loam). The installation procedure (in brief) is described below:

Installation procedure of GEE slabs

(1) Dig a trench (70-75 cm deep and 50 cm wide)
(2) Lay 9-10 inches (or more) of good soft soil (preferably sieved loam) before laying GEE slabs on top (do not use stony and sandy soil).
(3) Connect the GEE slabs end to end and bolt securely + all the earthing conductors (in addition, welding the joints together is preferred)
(4) Encase all joints with cement mortar (after connecting the earthing conductor(s) to the GEE slab joints)
(5) Now cover GEE slabs with 9-10 inches (or more) of good soft soil and tamp down gently with feet.
(6) Complete the installation by backfilling the rest of the trench with the excavated soil.
(7) Add water (the following day) to expedite soil compaction.

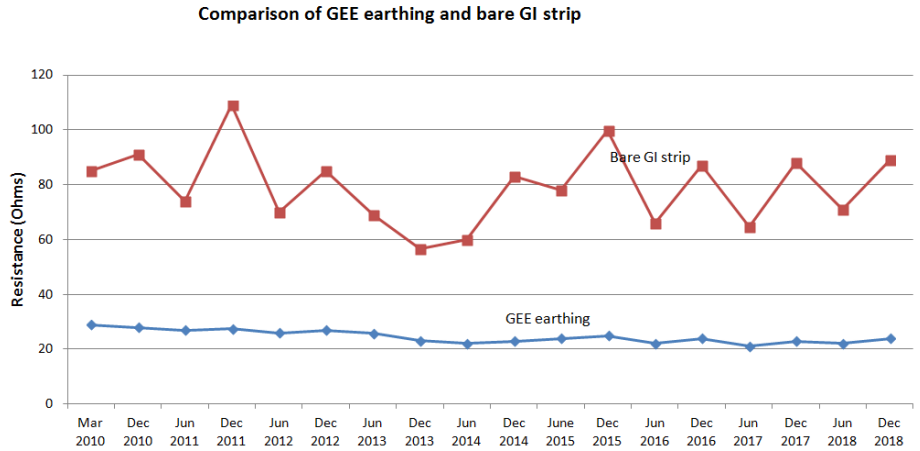
The GEE slabs can be used for all earthing applications such as those in: building/house earthing, power and telecom infrastructure, ICT infrastructure, lightning protection, industrial machines/equipment, etc.

In order to prove that GEE earthing slabs provide: (i) a reliable, durable, and maintenance free earthing installation, and (ii) a much better alternative than salt based pipe/plate/rod installations, the test results (over the last ten years) of an actual installation is presented in the graphs below.



The graph above shows the performance of a GEE slab earthing installation (i.e. 6 slabs) from September 2010 to Dec 2020. As can be seen, the earthing resistance gradually decreases over time (i.e. in tandem with natural soil compaction) and has stabilized to around 10-11 Ohms. It may be noted that the number of GEE slabs necessary for an earthing installation will depend primarily on the soil resistivity and the earthing resistance value demanded by the earthing application.

Further, in order to prove the effectiveness of encasing earthing conductors in conductive concrete, a study was conducted (over eight years) comparing the performance of: (i) 4.7 mtr GI flat directly buried in the ground, and (ii) 4.7 mtr GI flat encased in conductive concrete and buried in the ground adjacent to the first. The results are self explanatory as seen in the graphs below.



The performance graphs (left) compares (i) 4.7 m long GEE earthing and (ii) 4.7 m long GI strip earthing (i.e. bare conductor buried in soil).

Note: The two test installations are adjacent to each other so that there is minimal difference in site soil resistivity between the two.
From the above graphs, it is clear that the GEE earthing provides a stable earthing resistance while the bare GI strip of equivalent length provides a greatly fluctuating earthing resistance. It is also clear that encasing GI flat in GEE earthing material (conductive cement) greatly lowers the earthing resistance as compared to directly burying an equivalent length GI flat in soil.

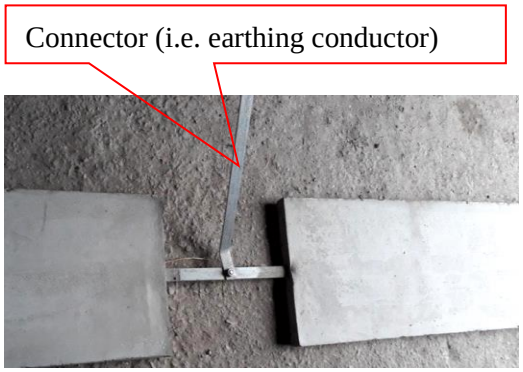
From the above comprehensive field tests, it is clear that the GEE earthing slabs provide a reliable, durable, and maintenance free earthing installation. However, since it is based on science (and not magic!) as with any other earthing technology, the installations have to be done properly using low resistivity backfill soil (i.e. loam) and with adequate number of GEE slabs (according to the site soil conditions and the earthing application).

Another major advantage offered by GEE slab earthing is the lower surge impedance which is particularly important in efficiently dissipating lightning and switching surges. This is of paramount concern, in power, telecom, and ICT infrastructure operations. The lower surge impedance is obtained because of the large surface area of GEE slabs in contact with the soil. This provides higher capacitance and thus lower impedance to surges and transients. Also, the electrode-soil contact resistance during surge dissipation is much lower as compared to pipe or rod electrodes. Pipe/rod electrodes also have the tendency to loosen (i.e. soil contact resistance is greatly increased) in the soil due to mechanical shocks caused on account of conducting and dissipating lightning strokes.

In summary, GEE slabs provide a safe, durable and reliable earthing installation in a maintenance free manner. It provides simpler and faster installation (since the need for digging deep pits is avoided). There is also no need to worry about leaking of salts/chemicals into neighbouring soil and water as in the case of salt based earthing technologies. Also for a given performance, GEE slabs provide a far more cost effective option.

(D) Earthing conductors and backfill soil

Based on earthing site observations and customer feedback over the last few years, we also sell earthing strips (GI flat 25x3mm) but availability should be confirmed in advance. This eliminates GI flat/wires purchasing and fabrication difficulties at site.



Note:
Each GI strip is provided with 12 mm dia. holes at two ends along with one matching GI nut and bolt set.
Since the GEE slabs use GI flat as back-bone earth conductor (encased inside), GI is the recommended earthing conductor material. ***Note****: Joining Copper and GI conductors will result in joint corrosion (deterioration) over time.*

Further, based on earthing site observations and customer feedback over the last few years, the main installation problems are seen to be on account of the following:

(i) Majority of the sites are comprised of rocky and/or sandy soils (i.e. high soil resistivity). Low resistivity backfill soil is not available at site (must be brought from elsewhere).

(ii) Majority of the sites (especially in urban areas) have space constraints. Not enough space for adequate quantity of GEE slab installation.

(iii) Many (if not most) earthing installations and done without sieving the backfill soil. This is mainly due to lack of sieve equipment and labour at site. Moreover, soil it often wet and difficult to sieve.

To overcome these problems, a low resistance backfill soil has also been developed for use with GEE earthing slabs. This backfill soil is essentially loam soil that is crushed, sieved, and mixed with carbon powder (*availability should be confirmed in advance*).

(1) Weight per bag = 30 kgs

(2) Packaging = Polythene bags

(E) Other important notes/recommendations for GEE earthing slab installation

Please note the following points:

(i) If space permits, avoid installing the GEE earthing slabs very close to concrete and stone walls. Keep at least 2-3 mtrs distance away from wall where possible. Concrete and stone walls will not facilitate efficient conduction of fault currents (in the event of faults). Earthing resistances will generally be higher when GEE slabs are installed close to walls.

(ii) If space permits, the GEE slabs should be chain linked in a straight line although a gentle curve will not make a very significant difference. Installing GEE slabs in two parallel lines/rows that are very close to each other is **not** recommended (i.e. the area of influence of the two rows will overlap and will therefore not provide the full benefit).

(iii) It is recommended that at least six GEE slabs be installed even for simple installation as a minimum standard (even where soil conditions are excellent). This is to safeguard against any earthing resistance fluctuations that may occur in the future due to variations in soil moisture content, temperature variations, site soil disturbances, etc. Moreover, sensitive electrical and electronics may also be utilized by the residents of the pertinent house in the future (even if not be foreseen in the near future). The more GEE slabs installed, the better the earthing (better safety and protection). ***It should be noted that six GEE slabs will not be sufficient where the soil is rocky or sandy.***

(iv) There are no magical earthing products! As with any technology, GEE earthing slabs must be installed duly in accordance to the manufacturer's recommendations for best results.

(v) For earthing conductor, GI flat should be used to connect to the GEE slabs (which uses GI flat as the central conductor within). Using copper earthing conductor will result in corrosion of the joints over time.