Feng™

Footprint Engineering Inc.
81019 Maitland Line
Clinton, ON N0M 1L0

519-240-6334

Commercial Licensing Program

In this document:

1. About Footprint Engineering ("Feng")

Footprint Engineering ("Feng") offers Value Engineering ("VE") Systems designed to lower the carbon footprint of a project, which in turn lowers project cost and reduces overall project schedule.

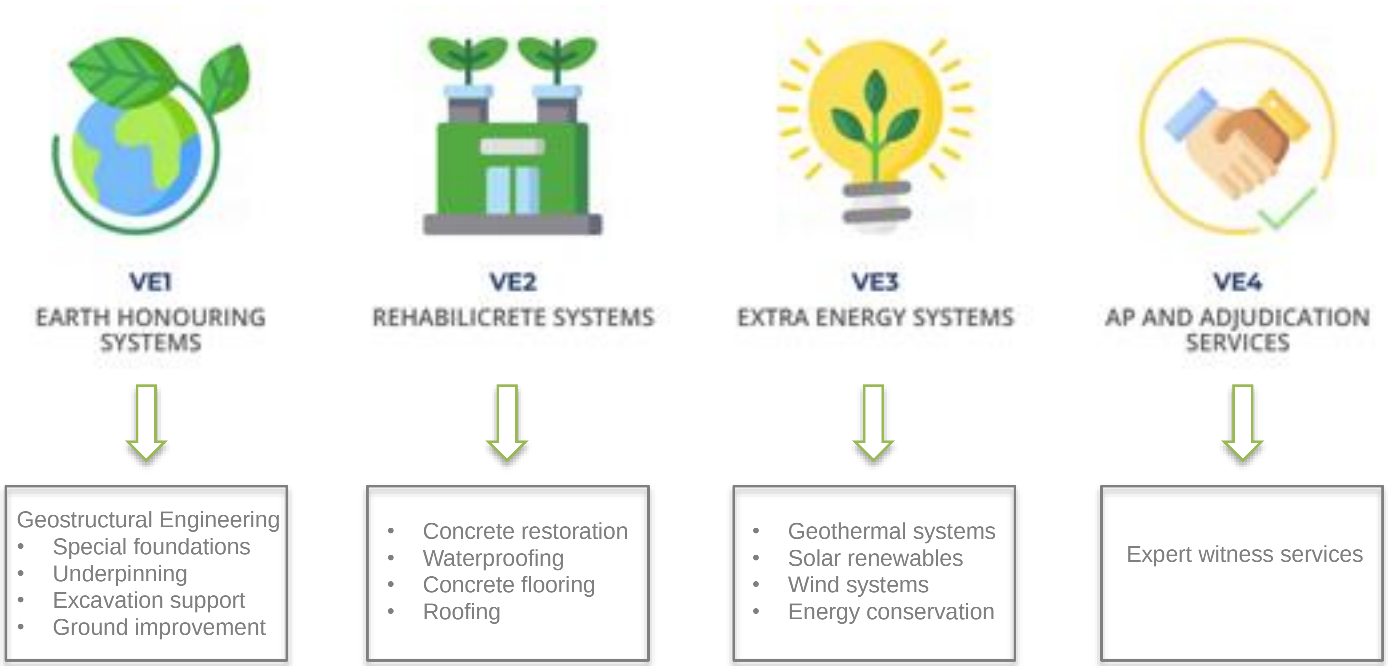
The lower use of carbon materials (such as concrete and steel) in the Built Environment is a goal all designers can embrace. The goal of a resilient design always starts with better systems choices.

While cost-savings generally drives stakeholders in the planning and design of projects, including those that use the Earth's precious natural materials, Feng believes that value can be found in other project areas including taking measures to increase functionality, lower the cost of materials with a view to lowering labour and equipment costs, reducing carbon-based fuel consumption, and increasing the life-cycle of the finished project. This is accomplished through the licensed use of Feng's patented VE Systems and/or custom VE Systems, in consultation with Feng's advice network of experts ("Feng Associates").

The network of Feng Associates includes strategically selected detailed engineering design firms and contractors, subject matter experts, and strategic product and system design partners – which collectively focus on helping clients decide on and execute the right system choice. Together with its Feng Associates, Feng consults on Feng systems, provides the best products, and oversees Quality Assurance (“QA”) of a system choice from design to execution.

2. Value Engineering (“VE”) Systems

Feng’s VE Systems are offered in 4 interrelated areas:



3. FePatents

Feng’s business activities include:

i. Consulting services in each of the VE Systems categories; and
ii. Commercial licensing of Feng’s Intellectual Property (“FePatents”).

The FePatents cover specific pre-engineered VE Systems, are protected by patent applications, patents, and industrial design applications, and are detailed in Feng’s publicly-available RSS documents.

4. Commercial Licensing of FePatents

As a result of the filed patent and industrial design applications, Feng has the right to grant third parties the ability to make, use, and sell the inventions claimed in those applications.

Feng offers its trademarks, patents, and industrial designs, and corresponding applications to select owners and developers, allowing those licensees to make and use Feng’s cutting-edge and cost-saving inventions alone or in conjunction with other site solutions.

The full range of FePatents are available as a package for licensing at a set yearly rate plus per-project fee, and can be used alone or combined with Feng's consulting services in each of the VE Systems categories.

Feng offers licenses of its FePatents to select owners and developers at the rate of CAD $25,000 yearly, on a per-country basis, and renewable at the option of Feng. A per-project royalty is paid by the licensee to Feng, at a rate to be negotiated based on a fraction of the expected savings (e.g. on a sq ft or another appropriate basis).

5. What technology is available to be licensed?

1. **<u>FeHDPlank</u>TM:** A unique green method of repairing corrugated steel pipes (CSPs), including culverts, sewers, and tunnels

<u>Problem:</u>

For more than a century, a third of drainage culverts installed have been CSPs in round and pipe-arch shapes. The service life of a CSPs varies, depending on coatings, thickness, climate, maintenance, pH on water flows, and the condition of the surrounding soil. Many are now reaching the end of their useful life following installation in the 1950s and need to be repaired, replaced, or refurbished before failure.

Culverts can be repaired or refurbished by building a new culvert or digging the existing pipe up and replacing it. But, these methods are costly and time-consuming. Open cut methods are impractical because of traffic volume; the road will likely have to be closed during open cut operations, terrain, or climate. trenchless replacement technology. Trenchless replacement technology allows culverts to be replaced with minimal disruption to traffic flow on any roadway above the culvert and with less impact on the waterway the culvert drains into, but "pipe bursting" techniques are destructive to the host pipe, rendering the host pipe effectively useless to provide support or peripheral protection to a new liner pipe. Slip liners, where a plastic liner is pulled through the interior of the host pipe, has difficulties associated with pulling the liner through a corrugated pipe.

<u>How it's solved:</u>

The FeHDPlank system allows for specially-manufactured interlocking plastic planks to be positioned within a host pipe forming a liner. Rebar is installed and attached to the host pipe for supporting the planks. A non-shrink grout is installed in the spaces between the liner formed by the interlocking planks and the host pipe so that the rebar is encapsulated with the concrete and so that the planks are immovably secured.

This invention provides an environmentally conscious, green solution wherein culverts of host pipes of different sizes can be repaired by the same method, using the same structure and components.

The environmental advantage, convenience, low cost, and ease of installation of this system makes it highly desirable. It's a one-size-fits-all solution – the only difference in repairing host pipes with different diameters is in the number of planks and amount of rebar and cementitious mortar that must be used.

Corrugated culverts in need of replacement can be repaired and in some instances their life may be extended by up to 75 years or more.

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2. **FeSpiral™:** Apparatus for repairing culverts and pipes using Fiber Reinforced Polymer (FRP) Rebar

Problem:

Rebar is cast into concrete to carry the tensile structural load, which is necessary because concrete is strong in compression but relatively weak in tension. Steel rebar has traditionally been used for reinforcement, but more recently, reinforcement bar produced from continuous fiber, such as Basalt rebar, has been used as it is superior to steel in both pervious and non-pervious concrete, does not corrode, is 2.5x stronger in tensile strength than series 60 steel rebar of the same diameter, is environmentally safe, creates no environmental waste in the production process, and has a thermal expansion coefficient very close to that of concrete (unlike steel) which lessens concrete cracking as temperatures vary.

Importantly, steel rebar is not highly elastic, and forming 3D reinforcement structures (e.g. in or around sewers, culverts, pipes, and tunnels) requires a lot of labor to place the reinforcement in the proper location, secure it accurately, and lap the bars sufficiently.

How it's solved:

The FeSpiral is a green solution for building structures or repairing existing structures, such as sewers, culverts, pipes, and tunnels of various diameters and cross-sections, using fiber reinforced polymer (FRP) rebar, such as Basalt rebar.

The modulus of elasticity of fiber reinforced polymer (FRP) rebar is 15-30% higher than that of steel rebar, which allows for "spiraling" of the rebar. In the method described in the patent application, two lengths of FRP rebar are formed into spirals and coupled at cross over locations to form a unique structure to be embedded into or covered in a cementitious material for repairing a form or in new construction.

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3. **FeH2OLoc™:** Construction of shoring support wall and water management system

Problem:

Most temporary shoring walls are constructed as the site is excavated using a typical two-step process with temporary lagged soldier beams cantilevered, rakered, or tie back supported, ready-mix poured in place concrete caissons, sheet piling, soil nailing, plate girders, or incrementally placed reinforced structural shotcrete to restrain the soil during excavation until a permanent structure can be built.

A major problem with these temporary structures is that water leaks through walls' ties and joints. Given that the flow of water may be negligible or it may be unexpectedly large, accurately estimating the amount of water that may seep into a construction excavation site is challenging. Hydrogeologist's reports are often overstated, indicating more water than is actually present, and rarely accurately represents the final flow of groundwater that will result from a particular excavation. Engineers often assume high recharge to avoid responsibility and potential insurance claims. In response to this concern, water management installations commonly known as "bath-tubs" are installed to manage the hydrogeological challenges associated with the site outside of and not inclusive of the shoring wall installations.

Constructing a large concrete raft-slab bathtub to accommodate expected water based on a hydrogeologist report may cost several millions of dollars or more, depending on the size of the site. If the hydrogeologist's report is inaccurate and overly conservative, this extra expense of overbuilding a raft-slab to accommodate a large flow of water from excavation may be unnecessary. The added financial burden and heavy environmental toll for this type of construction may not even be required, but only after the fact is this realized when the flow of groundwater is less than the amount predicted. What is required is a less expensive, more environmentally friendly solution to shoring walls and managing an unknown or imprecise expected quantity of ground water in an environmentally sensitive manner.

How it's solved:

The FeH2OLoc is a green water-management earth retention shoring system, constructed with a top-down process that can be used for permanent below-grade structures. The system is well-suited to constructing below-grade portions of buildings where excavation lay-back is not practical or cost-effective, and can incorporate permanent lateral support from tieback anchors.

With FeH2OLoc, a single permanent waterproof shotcrete shoring wall is constructed in-situ using a top-down construction. The initial waterproof wall allows for a curtain grout application to seal off water after an assessment of flow, if the rate of flow exceeds a predetermined amount. In instances where the water flow from behind the wall is negligible or acceptable, no curtain grouting is applied, and this negligible flow can be used in local applications for gardens and other local green use rather than entering the municipal sewage system.

In particular, vertical piles with a coupled skeletal structure are finished with reinforced concrete, applied in a particular manner. The below-grade structure is constructed by excavating down part way, constructing a waterproof "lift" portion of the ultimate structure, excavating down another part way, constructing another waterproof lift portion in a manner to be tied in with the lift portion immediately above, and repeating these steps until the below-grade structure is constructed to the desired depth. After the completion of the wall, seeping behind the wall at ground level is measured and a determination is made as to whether curtain grouting is required.

Constructing a waterproof wall down to a depth where 'true' flow is measured, and having the option of applying curtain grouting at the base to seal off the flow, is a green solution compared to constructing double walls with a waterproof membrane, or installing a large and thick concrete slab bathtub to resist water pressure between footings and slabs and later pumping the water to a municipal drain. Building a single permanent waterproof shoring and support wall in accordance with this invention allows for a choice, dependent upon a flow of water coming from behind a wall.

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4. **FeTremie™:** System for forming permeable reactive barrier in the ground

Problem:

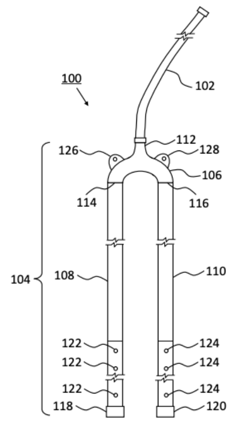
Underground permeable reactive barriers can be used for subsurface containment regions for containing hazardous waste or contaminated soil buried in the ground, and several techniques are known. Barrier placements that require digging a trench are limited to relatively shallow depths, cause considerable disruption of the surface and subsurface, and are not well suited for areas in which the subsurface contains large cobbles or consolidated rock formations. On the other hand, barrier placements involving the drilling of boreholes into the ground can be used to form barriers to deeper depths than is possible using trenched techniques, and the presence of cobbles or consolidated rock formations is not a major concern.

The use of staggered rows of boreholes to form a permeable reactive barrier is particularly attractive because greater depths may be reached, the barrier may be constructed close to property lines, and the subsurface composition is not problematic. Unfortunately, the boreholes tend to be relatively small in diameter (e.g., 6 inches), which causes problems when filling the boreholes with a substantially dry barrier-forming material, such as for instance a sand/iron filing mixture with a humidity level of about 20%.

Typically, the substantially dry barrier-forming material is fed through a conduit that is inserted into the borehole. The borehole is filled from the bottom up, and the conduit is withdrawn as the level of the substantially dry barrier-forming material in the borehole rises. The barrier-forming material is normally entrained in a flow of a gas, such as for instance air, and is fed into the borehole with a high flow velocity. This may result in a significant amount of the barrier-forming material being blown back up the borehole and into the surrounding environment. In addition, the height of the barrier-forming material in the borehole may rise faster than the conduit is being withdrawn from the borehole, causing the outlet end of the conduit to become stuck in the borehole.

How it's solved:

FeTremie is a system for forming a permeable reactive barrier for remediating groundwater, which includes drilling boreholes in staggered rows, and introducing a dry barrier-forming material into two holes simultaneously using a specially designed filling tool with two delivery conduits shown below.



In particular, dry barrier-forming material is introduced into the tool at an initial flow velocity through a source conduit and is sent through a flow divider before exiting into two boreholes. The filling tool is placed in two boreholes and the dry barrier-forming material exits at a lower flow velocity than the initial velocity, while the tool is simultaneously raised, thereby solving the problem of stuck conduits and material blow-back.

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5. **FeBTUCell™:** Innovative ground heat exchanger

Problem:

Geothermal energy is the second most abundant source of heat on earth and is a green source of energy. Geothermal piles made of concrete or steel with a wellhead and a U-shaped conduit in the center for carrying a fluid such as water, alcohol, refrigerant perform a function, but their ability to capture heat from the surrounding soil is limited and depends on the type of soil in which the pile is housed.

The presence of a groundwater table can facilitate heat transfer with geothermal piles because thermal conductivities of water and soil are orders of magnitude higher than that of air. Saturated soil is a more efficient medium for heat transfer than dry soil. Furthermore, having a greater surface area in which to collect energy and a medium to augment the transfer is advantageous. However, a groundwater table is not always present where needed.

How it's solved:

FeBTUCell is a heat exchanging system and provides for an artificial water table to simulate the presence of a groundwater table and increase geothermal pile heat transfer efficiency. This artificial water table is in the form of an in-ground vessel containing water for collecting heat from the surrounding ground, and contains a geothermal pipe or pile for collecting heat from the ground heated water within the artificial water table.

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6. **<u>FeSolarCurb</u>™:** Frame with plenum for melting ice from a photovoltaic array

<u>Problem:</u>

Solar panels (photovoltaic (PV) modules or arrays) are commonly installed on the roofs of houses or office buildings, allowing for widespread deployment of solar power systems even in densely populated cities or areas that have limited available ground space.

Various mounting systems are known for securing PV modules or arrays to sloped or flat roofs, but a problem that is commonly encountered in cold climates is that snow, sleet, ice etc. tend to collect and build up on the glass covers of the PV modules. Snow, in particular, severely reduces the intensity of sunlight being received by the PV cells, thus making solar panel power generation inefficient during winters and in cold climates.

<u>How it's solved:</u>

The FeSolarCurb is an innovative system which includes a frame for supporting a PV module at a distance from the installation surface (such as a roof), and having a plenum for directing a flow of warm air under the PV module for melting snow and ice. The plenum has an inlet port for receiving a flow of warmed air, and is configured to distribute the flow of warmed air through the openings in the frame sidewall into the interior volume behind the PV module.

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7. **<u>FeHeligent</u>™:** Pile wall system

<u>Problem:</u>

Constructing a shoring wall in the ground using only concrete piles can be problematic in water-saturated ground material.

Tangent walls are well suited for use in urban areas and on constrained sites, in which the excavation pit may extend to the property line, and where traditional retaining methods would encroach the adjoining properties. However, tangent walls cannot be used in high ground water areas due to the difficulty of forming bore holes of sufficient depth in water-saturated ground material, and the fact that water can pass through the space between adjacent piles unless the spaces are grouted.

If the shoring wall is to be reliable and safe for excavating a region within an area that is enclosed by poured concrete piles in water-saturated ground material, then constructing a support wall requires innovative measures.

How it's solved:

FeHeligent is a pile shoring wall that includes tangent concrete piles formed in the ground at an excavation site in combination with 10-50% helical piles.

The relatively small diameter of a helical pile shaft is not well-suited for holding back ground material surrounding an excavation site, and so cannot be used alone to form a reliable shoring wall. However, when used in combination with concrete piles, helical piles can be used to construct tangent walls in high ground-water areas.

Each helical pile has a bottom portion with helical flights for screwing the helical pile into the ground. The helical flights of each helical pile are exposed to the surrounding soil below the concrete piles, and increase resistance below an excavation depth when the site is excavated on one side of the shoring wall.

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