

FirmaMent

UNITED STATES
MONGOLIA
CAMBODIA
INDONESIA
NEW ZEALAND
CHINA



APSARA Development

Minnesota, USA

Used in North America since the early 1970s and in Asia since 1996

FirmaMent (FM) is an organic enzyme that alters the soil minerals causing a catalytic binding of soil particles into a high-density, water impermeable long-lasting and durable layer of stabilized soil that replaces the sub-base and base of roads. Unlike chemicals or other inorganic products which temporarily hold soil materials together but do not last under weathering, water penetration or traffic conditions, FM has a proven history of durability and, when sealed, will last indefinitely preventing potholes and wash boarding. Very high rainfall jungle conditions with clay soils requires sealing of roads with an inexpensive chipseal layer. In temperate conditions sealing is optional but recommended for more heavily trafficked roads.

Soil Requirement:-

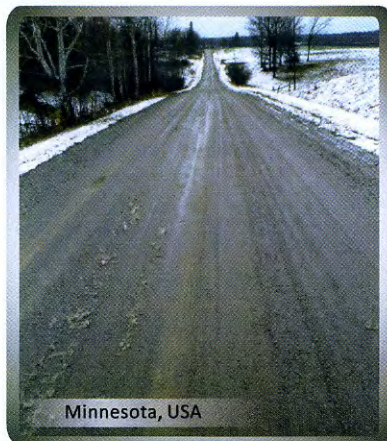
FM works with a wide range of soils and is not affected by heat in tropical conditions or excessive cold and snow in extreme temperate climates. FM will not work with high organic soils such as peat or loam nor will it work with pure sand.

Roads should have between 20-30 percent clay fines and the remainder mix of rock and sand. Most areas of the world have a mix

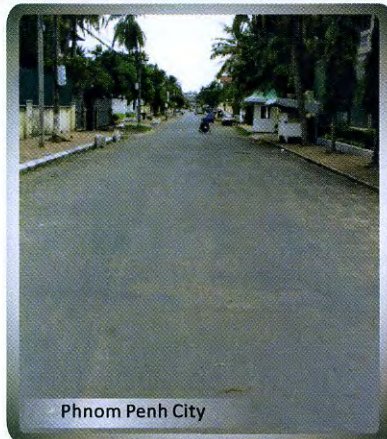
very close to this specification so it is normally not necessary to bring in materials but occasionally additions of clay may be needed. In the end, FM allows for a high range of variation in the amounts of the soil components.



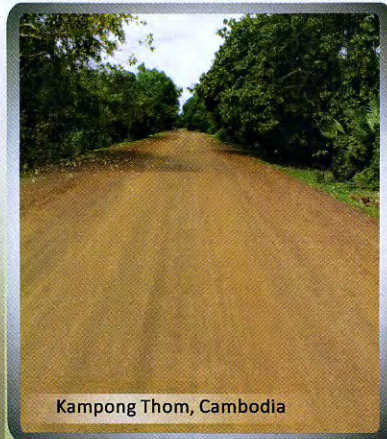
Mongolia Highway



Minnesota, USA



Phnom Penh City



Kampong Thom, Cambodia

Benefits

- Cost effective - With a seal coat of emulsion and rock (chips seal) or asphalt, the cost of a road is approximately 25 percent of a traditional road with a sealer because only the local soil is used and there is usually no need to truck in aggregate as with a traditional road. FM bases do not require rock sub-bases or rock additions.
- Low maintenance - Typically an FM road will not require any significant maintenance for approximately five years depending on road use. The FM layer remains durable for approximately 15 years without sealer coats and many years longer when sealed with chip seal or asphalt. The only maintenance that might be needed is a one time per year grading of the surface just to skim off loose materials. If the road is sealed with chip seal, normal weathering and traffic will have damaged small areas which are very simple and quick to repair unlike asphalt.
- Roads can be built without stopping traffic.
- Creates a dense road base resistant to water, weathering, erosion and wear. FM roads are semi-rigid and do not crack or settle but "float" over any soft areas
- High load bearing capacity - 15 tonnes per axle. High compressive strength and increased angle of friction. Because FM layers have consistent high density and particle bonding (cementation), penetrometer tests will show greater than 22 tonnes per square foot and higher angles of friction in FM layers regardless of the soil characteristics. CBR values are increased well beyond normal requirements from 60 to 130.
- FM works with nearly all soils except pure beach sand and high organic content peat. Proven results with high clay content soils, granular soils and most mixes of these soil components.
- Simple application. Apsara provides long-term technical support on site providing workers/contractors with the training needed on the method of application, improved road designs and sealer application.
- Environmentally safe and completely harmless to plants, animals and human, non-toxic and non-flammable

Important Note For Palm Oil And Other Agricultural Estates

Using stone for stabilizing roads is expensive and requires constant maintenance with grader and compacter time. Stone also slows the travel speed of equipment and the rougher more uneven surfaces of the roads causes fruit spillage, increased fuel use, damage to tractors, trailers and trucks and overall lower productivity. The smooth FM roads eliminate this problem. Therefore, the reduced cost of roads and machinery maintenance over a period of approximately two years will usually come close to equaling the total cost of the FM road construction.

Most estates will suffer a decline in harvesting during the rainy season because of impassable roads causing loss of crop. FM roads are all-weather 365 day-a-year useable. The recovery of the formerly lost crop in about one year will usually equal the cost of the FM road.

The result of these savings and the long-term reduced maintenance of the FM roads means that in less than two years the cost of the FM road is recovered and subsequent years savings are additional income. The overall efficiency of production is consequently increased.



East Kalimantan 12 meter wide main mill road

- FM is ideal for the soil conditions in Southeast Asia where soils are generally heavy clay, clay and sand or laterite, and other unstable soft soils that are subject to water damage.
- FM is traditionally used for rural roads and, left unsealed, results in roads that last for 10 - 15 years with minimal maintenance. Because of the unstable nature of clay soils it is recommended that roads with these soil characteristics be sealed with **Chip Seal** (emulsion and chip rock) or asphalt.
- New Zealand and some areas of China have abundant granular material which is a highly desirable soil content. This kind of coarse soil and rock adds considerable strength to any road but must be combined with 20-30 percent clay fines which fill voids and greatly enhance the cementation action of FM. Therefore, in New Zealand and in China it is sometimes necessary to truck in sufficient clay to provide the ideal mix.
- Calcium additions to soils where flooding or low quality soil has seen vital calcium and other minerals leached are sometimes necessary in the form of agricultural lime or cement powder. One kilogram per square meter of either lime or cement will guarantee that there is sufficient calcium to speed the soil bonding and provide additional strength. Either of these materials will add only a few cents per square meter to the road cost but provide a high level of confidence that the road will be stronger and cure faster.
- Sealing an FM road will completely eliminate dust and will extend the life of the road indefinitely with minimal maintenance. The only repairs will generally be on the sealed surface which can be damaged by normal weathering and heavy machine damage. Small area repairs to sealed surfaces can be done by hand using cold emulsions and additional rock if necessary. **Chip Seal** is recommended as a sealer because of its low cost, ease of application using cold emulsion and high durability exceeding that of asphalt. Chip Seal is also easier to repair than asphalt.
- For highways FM serves as the base making it unnecessary to truck in aggregate thereby reducing the overall road cost and resulting in a stronger base than a traditional road and one that will not crack or settle because of water penetration. An FM base will extend the life of asphalt by approximately two times the normal life. The strong and dense FM base allows application of reduced thicknesses of cement and/or asphalt surfacing for highways.

EQUIPMENT NEEDED

- One motor grader
- One soil mixer - optional
- One water tanker
- One vibrating compactor

STEP ONE

- Take up 20 cm of an existing road surface, or place the equivalent of 20 cm of new soil on a road and mix to a homogenous state either with a motor grader or soil mixer.

NOTE : 20 cm of loose soil equals a 15 cm compacted layer. Spray with the correctly calculated mixture of FM and water. Continue mixing the soil with a motor grader or soil mixer.

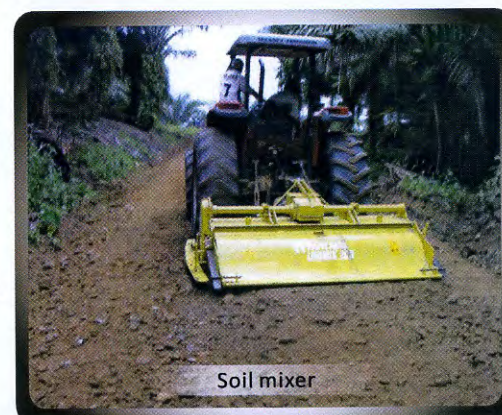
NOTE : Using a soil mixer reduces the grader time by at least 50 percent and speeds the construction process significantly while producing a more homogenous mix of soils. If using a soil mixer the motor grader need only configure the basic road followed by scarifying the surface to a depth of 20 cm then use the soil mixer for several passes until the entire surface is mixed and the FM/water mixture sprayed down evenly followed by further mixing.

STEP TWO

- Using the motor grader configure the drains and final configure the road with the desired camber/crown.

STEP THREE

- Using a vibrating compactor begin the compaction from the outer edges first working the middle. Once several passes have been made using the vibrator, smooth roll to the final finish. The road is now complete and can be opened to traffic.
- If it rains before compaction, work should be stopped. Any rain after compaction will have no effect because the surface is sealed and only a small amount of rain will enter the road surface.
- On day two smooth roll the road again to a final smooth and clean finish. If the road has been damaged overnight and needs to be re-worked, just have the grader recamber the road and smooth roll.
- FM roads harden over a period of approximately four days depending on environmental humidity and rains. The road can be reworked for several days by just adding plain water to keep the necessary moisture in the mixture. Hardening of FM roads continues until nearly all moisture has evaporated from the treated layer in 30 - 60 days. The rate of hardening measured with a penetrometer increases dramatically from day two to day four after which the rate of increase is more gradual.
- Measured with a penetrometer the Unconfined Compressive Strength of an FM road after four days is beyond 22 kg per square centimeter (22 tons per square foot). The penetration force exceeds 36 kg per square centimeter.



KALIMANTAN

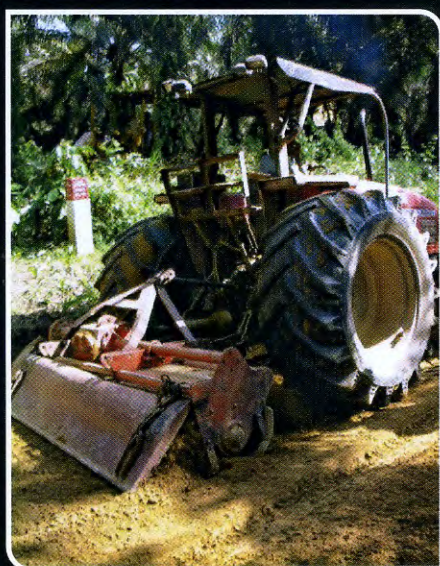


MIXING FM AND CALCULATING THE AMOUNT OF WATER

- One liter of FM will treat 200 square meters of soil to a final layer of 15 cm. Therefore, just calculate the total area to be constructed in one day and determine the amount of FM needed.
- The amount of water depends on the dryness of the soil. However, good rule of thumb is to add one liter of FM to 1,000 liters of water. If the soil already has considerable moisture in it, reduce the amount of water added to FM to 500 liters per one liter of FM. After FM/water mixing with the soil we should be at approximately 2 - 3 percent below the optimum moisture content. The test for proper wetness is to pick up a handful of wetted soil and squeeze it to a ball and then toss it in the air and catch it. The ball should fall apart. If it holds together after several tosses, the soil is too wet and should be re-rolled or mixed to allow the soil to air dry.
- EXAMPLE : A section of road 500 meters in length and 4 meters wide equals 2000 m² divided by 200 equals 10 liters of FM and 10,000 liters of water. If you water tank holds 5,000 liters of water, add 5 liters of FM and spread over the entire amount of soil to be treated. Repeat the process with the second tank of water. Mix thoroughly and complete the process.



INDONESIA





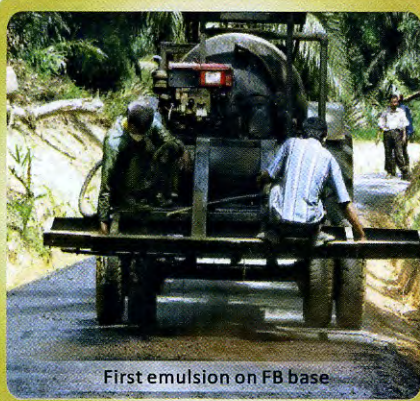
MALAYSIA

ROAD SURFACING OPTION



FM base

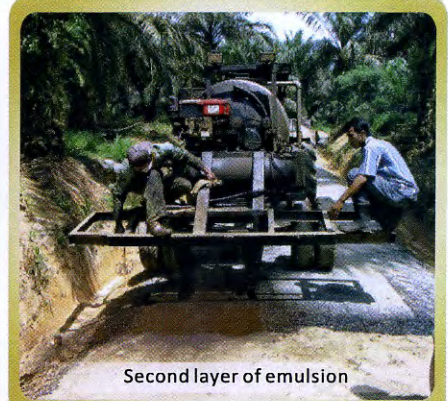
FM roads can be surfaced with any traditional materials from cement to asphalt to chip seal. Because FM roads are a soil base that does not crack or settle, any surfacing will last approximately two times longer than normal. Traditional road bases tend to settle over time with exposure to water from below or above and with traffic pounding. This causes the base to move and give rise to cracking. FM is a solid layer and does not allow for settling. For this reason an asphalt or chip seal road surface, for example, will hold up better and the only deterioration would be from normal weathering or extraordinary damage from machinery such as a bulldozer.



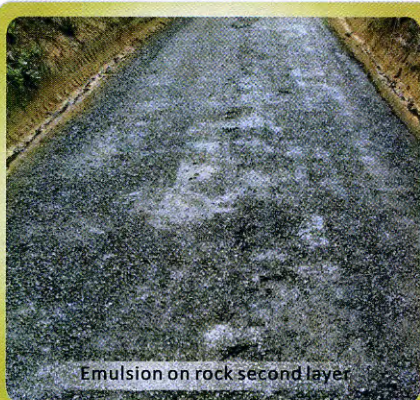
First emulsion on FB base



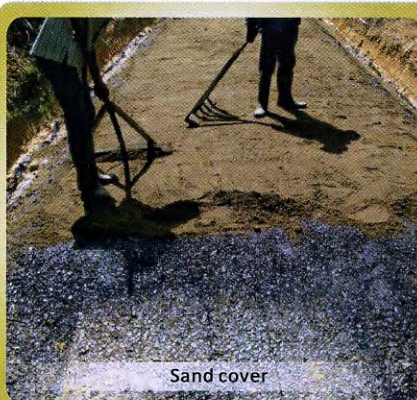
Chip rock on emulsion



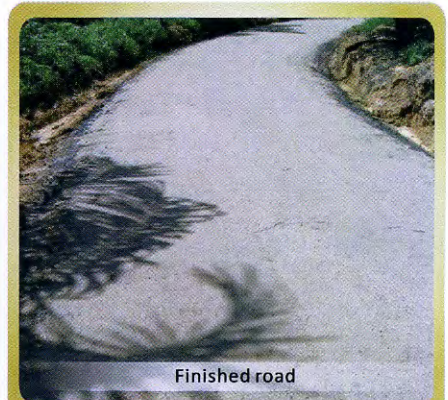
Second layer of emulsion



Emulsion on rock second layer



Sand cover



Finished road

CHIP SEAL

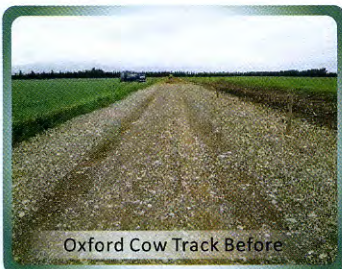
- Chip seal is a cheap but durable form of surfacing for all roads. Chip seal tends to hold up better than asphalt because the emulsion fingers down into the surface of the FM treated layer binding better to the surface and sealing the road permanently. The layer of chip rock covered by a second layer of emulsion followed by a thin layer sand creates a harder surface where vehicles are essentially running on rock rather than soft asphalt. This offers better traction and after approximately six months the surface is similar to asphalt although somewhat less than asphalt but considerably harder.
- Chip seal can be applied after the initial drying period of the FM treated road - anytime after four days. Cold emulsions available widely are most suitable because they do not require any heating and can be stored for use when convenient.
- Step to apply chip seal include:
 - Spray 0.7 liters of emulsion per square meter on the road surface;
 - Cover with chip rock 1 to 1.5 cm in size;
 - Spray a second layer of emulsion over the rock at 2.5 liter per square meter. Large rock or a second layer of rock will require additional emulsion but this is done based on the road and user's requirement;
 - Spread a thin layer of crusher dust or coarse sand over the surface. Either of these materials serve the purposes of filling the voids between rocks adding strength to the surface, and allowing the road to be used immediately for light vehicles. The emulsion hardens after approximately 8 hours.



NEW ZEALAND

Cow track preparation

Many cow tracks have substantial amounts of rock that are highly undesirable in any track as they resurface and loosen. Use of an FAE type soil mixer/rock crusher completely eliminates the rock problem by crushing everything to small chunks that are ideal for road and track building creating a good mix of fines, granular and rock materials.



Oxford Cow Track Before



Oxford Cow Track After



Rotherham Cow Track Before



Rotherham Cow Track After

Cow Tracks on New Zealand farms are essential to prevent hoof disorders as cows travel long distances two times a day for milking. Traditional cow tracks are expensive to initially construct and expensive to maintain. Using FM results in a smoother more cow hoof friendly surface which can be adjusted with minimal additional material such as clay or lime, to accommodate soil conditions that are not ideal. The weight from a cow walking at normal speed results in 10 tonnes per square meter. An adult man exerts about half that pressure. FirmaMent tracks will carry loads of up 237 tonnes per square meter - many times more than that needed by cows. The resulting surface is expected to remain durable for many years with no maintenance with the exception of removal of cow manure.

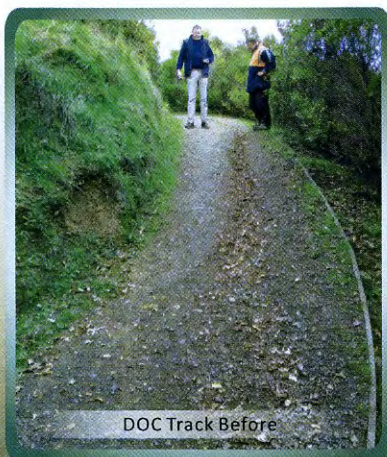
Secondary or industrial use roads such as this quarry road are typical uses for FM. The quarry road had very high rock and granular content with clay added from abundant supplies of loess and other clays found almost everywhere nearby in New Zealand. The resulting road will support approximately 20 tonnes per axle and have a CBR values of 90 - 150 when fully cured after 60 days. In the meantime, the road can be used normally to great benefit in adding to the initial construction compaction. As any road engineer knows, all roads are different and require tailor made solutions. FM works well with this flexibility making it possible to construct forestry and mining roads which represent uniquely challenging environments and wear conditions. With an increase in treatment depth, use of small amounts of cement and design care, such roads in difficult areas are successful. Indonesia is a prime example of building in the most difficult circumstances with nearly 95 percent clay and in very wet conditions. Forestry roads in the U.S. in commercial logging areas have traditionally used FM because of this durability and because FM roads are completely harmless to the environment and can eventually be returned to nature.



Havelock Quarry Road Before



Havelock Quarry Road After



DOC Track Before

Department of Conservation (DOC) tracks found throughout New Zealand's scenic countryside are costly to construct and especially to maintain. Maintenance costs for a safe and durable track can be reduced by as much as 90 percent with treatment with FM. The tracks are not subject to traffic damage but from rains and erosion which are both overcome with a durable surface covered by an appropriate sand surface or no surface at all. With simple appropriate equipment and a small crew approximately 2 km of track could be treated in a day depending on how much re-construction or re-routing needed to be done. Tracks with FM treatment should last a minimum of 10 - 20 years with little or no maintenance.



DOC Track After



NEW ZEALAND

Lake Victoria



Lake Victoria after quake



Bentonite added



Compacting bentonite and FM



FM layer complete



Lake Victoria June 2012

When the devastating earthquakes struck Christchurch, the precious Lake Victoria at Hagley Park was drained as cracks opened on the surface and water escaped to underground aquifers. The remaining silt and effluent built up since the last clean-up of the lake would not have sealed the lake again and needed to be replaced.

Conventional pond or lake sealing worldwide has been the use of clay liners because of the unique density qualities of clay and self-sealing character. Plastic or other artificial liners tend to degrade, leak and break and are very expensive to install. The Christchurch council selected FM as the method of sealing along with bentonite clay. Fortunately New Zealand has an abundant supply of bentonite - the same clay used by oil well drillers for sealing well casings. Bentonite, when treated with FM, results in a doubling or more of the strength and self-sealing ability which is expected to remain durable for another 150 years or beyond. FM treated clays have a permeability rate much lower than the requirements of New Zealand authorities. Effectively this means that it would take years for the first centimeter of FM layers to become wet. The use of FM also guaranteed that the lake will remain completely non-toxic to any living creature or plants. Lake Victoria sealing was completed in February 2012.

Farm Reservoirs

With the rapid increase of dairy farms in New Zealand there has been a corresponding demand for water for cleaning and irrigation. New Zealand authorities have backed the construction of ponds to preserve water to last during the drier seasons. Ponds take up large portions of a farm hectare and are costly to build. The in-situ soils are usually porous and result in leakage which is costly to farmers who pay for the water. The solution is, therefore, to seal the pond with local clay - usually loess which is a reliable material when combined with FM. While conventional pond depths are between 2 and 3 meters with a one meter berm, with FM the pond can be built to a depth of up to 10 meters as has been done in the U.S. building reservoirs with FM. Most ponds would likely be built to a depth of 4 - 6 meters thus reducing the amount of land used and also the surface area evaporation. More depth means more weight of water on the clay/FM liner equaling more density and sealing.

Effluent Ponds

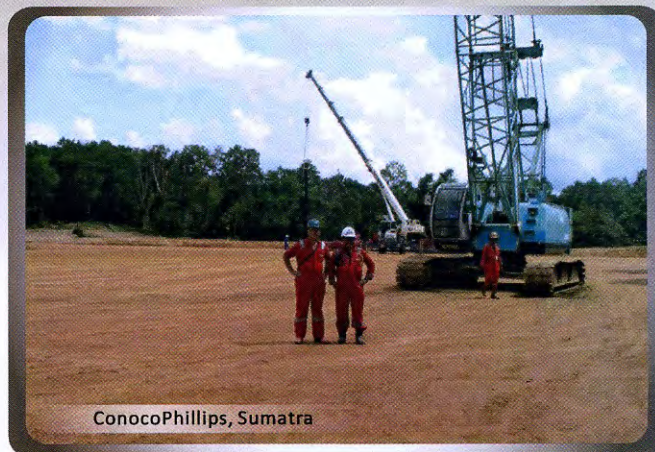
Farms are required to have effluent storage and degradation of the manure which is eventually used for irrigation re-applied as good fertilizer to grazing land. These ponds containing cow manure are not allowed to leak. As with reservoirs, the local clay and FM treatment will result in a no permeability thus protecting the aquifers.

Other Water Holding Ponds

In a relatively dry summer season it is often necessary for councils to preserve water for firefighting and other public service use. FM and clay is an ideal cost option which also permits making the ponds deeper, less obtrusive and conserving land use.



SUMATRA



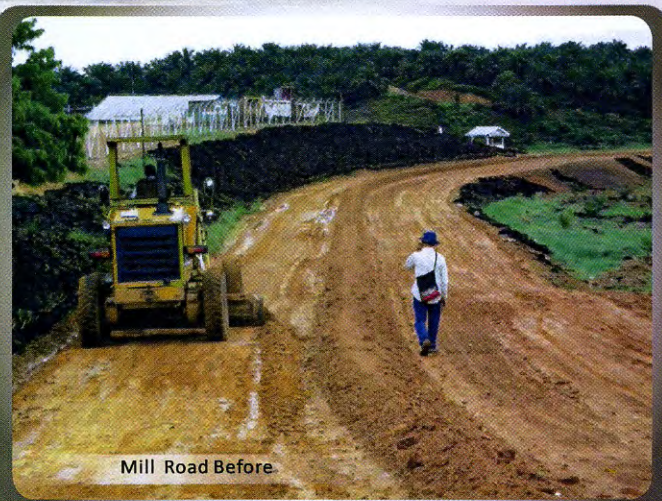
ConocoPhillips, Sumatra

Aspara Development has used FM to build 14 oil and gas drilling pads for ConnocoPhillips and other companies in Sumatra. Some of the sites are up to 7 hectares in size and others are 3 - 4 hectares in a single contiguous property intended to accommodate very heavy equipment, containers and use of large and heavy tracked and wheeled machinery. The photos here are typical of the sites. The crane was brought in the same day as the FM was finished, several days earlier than expected, and left no damage. The site was treated at 30 cm, double the normal depth, to support the heavier than normal vehicles and wear. The cost was a fraction of the conventional method of bringing in 60 cm of rock and each site was completed in days rather than months.

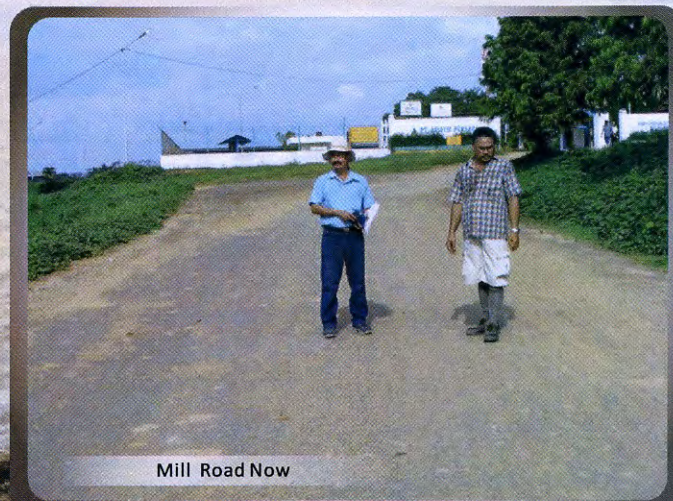


Tatley Oil, Sumatra

This road was newly cut and filled and then treated with FM in 2003 in Sumatra at an oil palm estate. The road is the only access to the factory and needed to handle approximately 300 trucks, tractors and trailers and crude palm oil haulers of 40 tonnes each day. The road was surfaced with chip seal and is seen in the photo as it remains today. Minimal surface repair has been done on the road approximately once a year in a few small areas of where the clip seal surface has been damaged. The FM layer has remained intact and undamaged for 9 years.



Mill Road Before



Mill Road Now

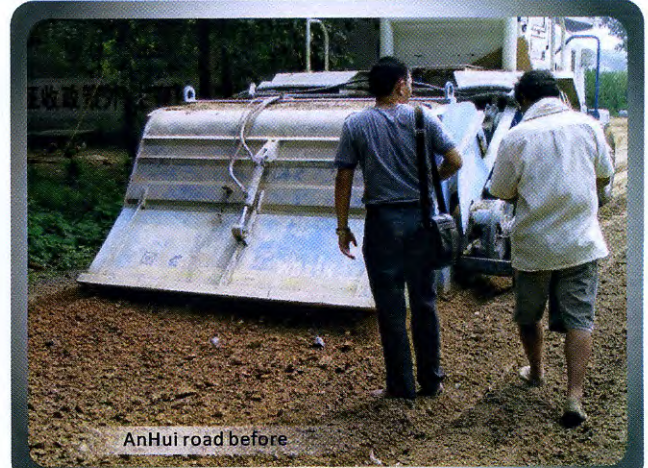


CHINA

China has diverse climate from heavy rainfall areas in the central to south to cold snow covered from central to the north. This road was built in the central area of AnHui province in a highly agricultural area with a heavy rainy season and difficult to navigate for at least 8 months of the year until 2011 when it was rebuilt with FM. A reclaimer (heavy duty specialized soil mixer) was used to prepare the road which was then chip sealed. The last photograph was taken in March 2012 after a long rainy season and considerable traffic. Government testing at that time confirmed Aspara Development testing of CBR with results from 110 to 130. This exceeds traditional secondary road CBR by 50 - 70. The AnHui road should need no maintenance for 5 - 10 years and the road has become the pattern for all the provincial roads. The city government has also approved FM for use in building the base for city roads.



AnHui original road



AnHui road before



FM completed



Chip seal

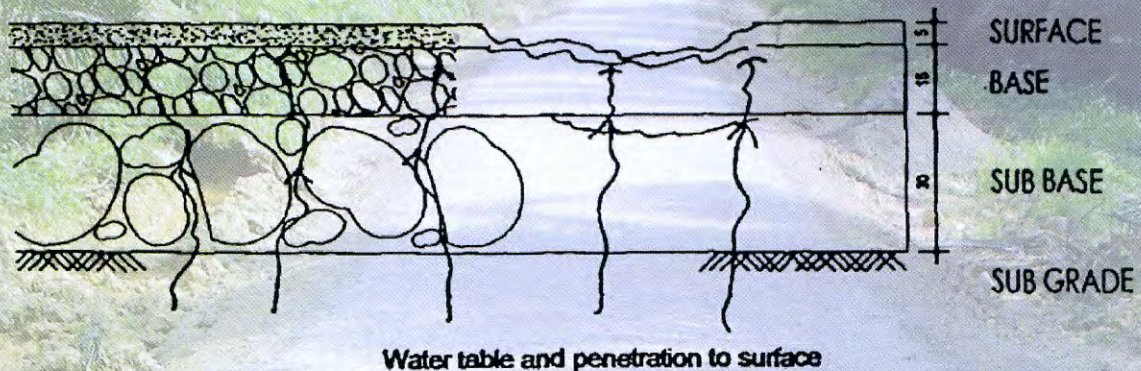


Chip seal



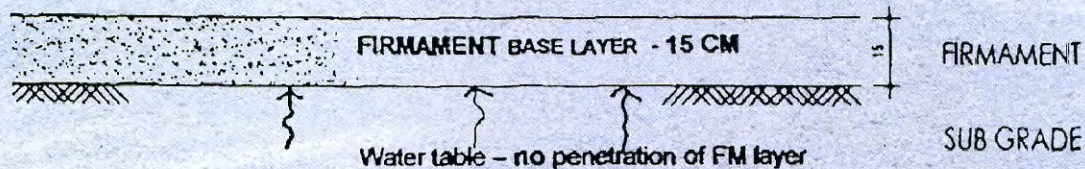
AnHui road now

POTHOLES



A disadvantage of traditionally constructed roads using several layers of aggregate and soils is that water is able to move upward through capillary action leading to soft areas and resulting pot holes

NO POTHOLES



An FM base is water impermeable and will remain solid and stable preventing damage from water action. Surfacing materials will last two times longer as a result.



APSARA Development

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