

What is Permazyme 11X Soil Stabilization Enzyme?

Permazyme 11X is a unique multi-Enzyme product specifically developed as an effective aid to the workability, mix-ability, binding and compaction of soil.

Permazyme 11X significantly improves stability in construction of roads, dams and many other related projects.

Permazyme 11X is a completely natural bio-degradable product. By its actions it alters and improves soils physical and chemical properties which result, in significantly less mechanical effort to achieve greater densities for compaction.

Permazyme 11X offers a convenient and low cost method for improving a soils strength and durability, enabling lower construction costs, less maintenance and greater road performance.

Permazyme 11X has ionic actions, which bind dust particles together to maintain a longer dust free environment.

1 liter of Permazyme 11X will treat 31 cubic meters of soil.

The benefits of using Permazyme 11X:

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|-----------------------------------|------------------------------|
| a) Reduced construction costs | b) Longer useful lives |
| c) Minimal road maintenance costs | d) Better wear qualities |
| e) Increased transport capacity | f) Greater passenger comfort |
| g) Lower vehicle operating costs | h) Reduced traffic accidents |
| i) Excellent environmental safety | |

Permazyme 11X Delivers!

For paved roads, stabilizing the base and/or sub-base layer with Permazyme 11X:

- a) Improves the soil structure sufficiently to achieve confirmed savings of greater than 25% in paved road construction costs.
- b) Strengthens the road structure of highways needing repaving and eliminates the need to remove and dispose of old asphalt. Recycling and stabilizing asphalt increases structure strength two to three times.
- c) Strengthens base layers and sub-base layers in preparation for chip - seal operations.
- d) Increases the capacity of the road surface to support heavy traffic loads.
- e) Reduces such common road surface problems as cracking and surface loosening.
- f) Reduces the cost of purchasing and transporting construction materials for road reconditioning by reusing in-situ materials and upgrading and improving poorer quality local soils.
- g) Extends the useful life of asphalt and concrete road surfaces and stabilizes highway road shoulders. Construction savings mostly achieved from reduced aggregate and hauling needs.

For roads remaining un-surfaced, stabilization with Permazyme 11X :

- a) Improves structural integrity and load capacity, and reduces the occurrence of serious defects such as pot holes and rut formation, resulting in fewer maintenance needs.
- b) Strengthens base layers and sub-base layers for construction or restoration of rural or forest highways.
- c) Decreases the loss of aggregate and fine material and lowers dust formation.
- d) Yields significantly more durable surfaces and longer road life on secondary roads

Environmental benefits:

- a) Minimizes material loss of surface gravel on soil roadways due to erosion or abrasion by traffic.
- b) Reduces the ongoing cost and environmental impact of the purchase, transport and spreading of replacement gravel.
- c) Minimizes the harmful production and use of crushed rock and historical mineral stabilizers in road construction and maintenance.
- d) Reduces fuel usage associated with frequent, short interval road repairs.
- e) Lessens the impact of open gravel mines and pits. Permazyme 11X allows maximum leveraging of existing sources.

Permazyme 11X delivers stronger, longer-lasting roads & lower costs than conventional road designs. It is also better for the environment.

How it Works:

Soils are chemical substances. They have a tendency to react with other chemicals if prevalent conditions are present. These reactions result from the attraction of positive and negative charges in the components of the soil and the chemical substances. Many times, compounds react with these charges of the soil to alter the overall property of the soil. These effects are brought about by electrolyte exchanges, differences in osmotic pressure gradients, electrochemical and physical effects on the colloidal activity of the soils. Physical effects are related to Brownian motion, laminar shear velocity and pore-size distribution, whereas, electrochemical effects are related to Van der Waal's forces.

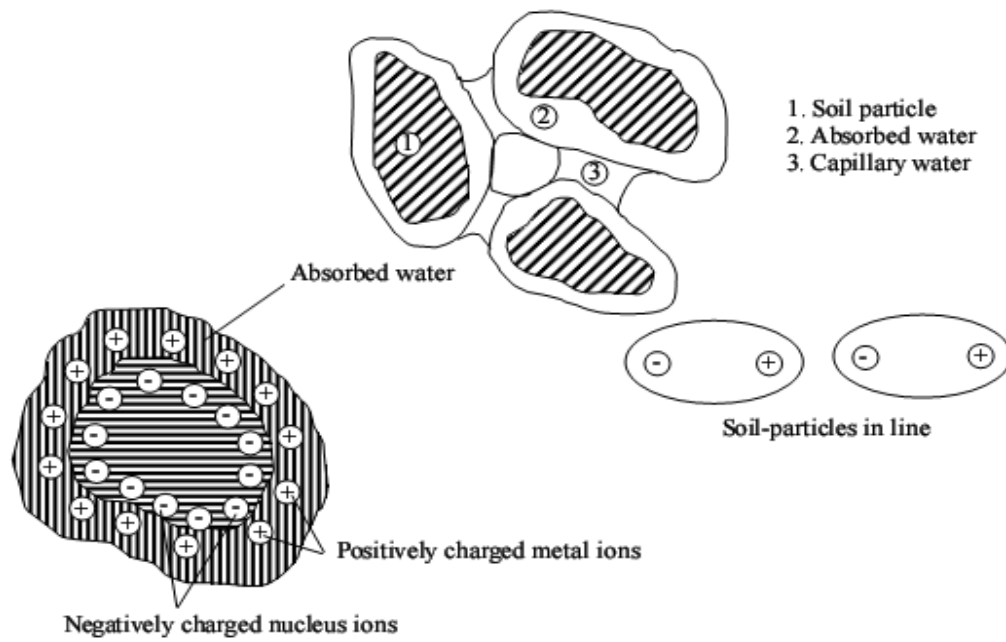
The addition of non-standardized stabilizers affects the shrinking and swelling properties of soils (clays). Some non-standardized stabilizers in use today are sulphonated oils, Ammonium Mineral pitches, Acrylic polymers and Enzymes.

Enzymes as a Soil Stabilizer

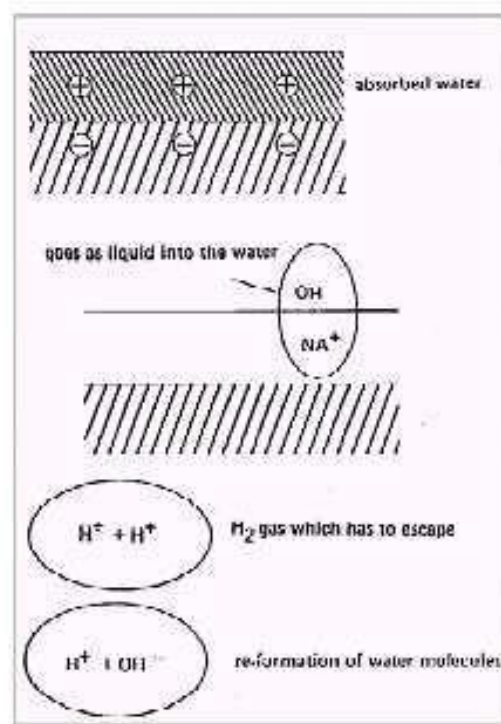
The Enzymes are absorbed by soil, initially causing it to expand and then to tighten. The Enzymes also help the soil bacteria to release hydrogen ions, resulting in pH gradients at the surfaces of the soil particles, which assist in breaking up the structure of the soil. An Enzyme is by definition an organic catalyst that speeds up a chemical reaction, that otherwise would happen at a slower rate, without becoming a part of the end product. The Enzyme combines with the large organic molecules to form a reactant intermediary, which exchanges ions with the soil structure, breaking down the lattice and causing the cover-up effect, which prevents further absorption of water and the loss of density. The Enzyme is regenerated by the reaction and goes to react again. Compaction of aggregates near the optimum moisture content by construction equipment produces the desired high densities characteristic of shale. The resulting surface has the properties of durable “shale” produced in a fraction of the time (millions of years) required by nature. When added to a soil, the Enzymes increase the wetting and bonding capacity of the soil particles. The Enzyme allows soil materials to become more easily wet and more densely compacted. Also, it improves the chemical bonding that helps to fuse the soil particles together, creating a more permanent structure that is more resistant to weathering, wear and water penetration.

The Concept of Enzyme Stabilization

- Enzyme stabilization is commonly demonstrated by termites and ants in Latin America, Africa and Asia. Ant saliva, full of Enzymes, is used to build soil structures, which are rock hard and meters high. These structures are known to stand firm despite heavy tropical rain seasons.
- Analysis by (A.R. Tolleson, E. Mahdavian, F.M. Shatnawi, N.E. Harman, September 2003, AN EVALUATION OF STRENGTH CHANGE ON SUBGRADE SOILS STABILIZED WITH AN ENZYME CATALYST SOLUTION USING CBR AND SSG COMPARISONS) for the treated and control specimens for various soil samples showed the strength change under the soaked condition ranged from negligible change for the samples with high fines content up to 140% strength gain for the soil sample with approximately 30% fines. The average strength gain was approximately 52% with a standard deviation of 58%. The test results for the subgrade soil samples tested under both dry and soaked CBR conditions indicated a greater average strength gain as a result of Enzyme treatment under the dry condition compared to the average strength gain under the soaked condition.
- The basic effects of the action of the Enzyme into the structure of the soil can be summarized as follows. Initially, the film of absorbed water is greatly reduced and in fact entirely broken, as shown schematically in Figures below:



Absorbed Water in the Structure of the Soil



Elimination of the Absorbed Water in the Soil

- The most difficult problem is raised by the presence of absorbed water in the soil that adheres to the entire surface of each soil particle. This film of water enveloping the particles, which ultimately governs the expansion and shrinkage of colloidal soil constituents, cannot be completely eliminated by purely mechanical methods. However, by means of temperature effects, addition or removal of water with mechanical pressure, it is possible to vary the amount of water held in this manner. Such variations are attended by swelling or shrinkage. This provides an ideal point of operation for the Enzyme.
- The electrostatic characteristics of soil particles will also have to be considered to understand the mechanism of soil-Enzyme interaction. As a result of lowering the dipole moment of the water molecule by the Enzyme, dissociation occurs in a hydroxyl (-) and a hydrogen (+) ion. The hydroxyl ion in turn dissociates into oxygen and hydrogen, while the hydrogen atom of the hydroxyl is transformed into a hydronium ion. The latter can accept or reject positive or negative charges, according to circumstances. Normally the finest colloidal particles of soil are negatively charged. The enveloping film of absorbed water contains a sufficient number of positive charged metal ions - such as sodium, potassium, aluminum and magnesium - which ensure charge equalization with respect to the electrically negative soil ion. In bringing about this phenomenon, the positive charges of the hydronium ion or of the negatively charged hydroxyl ion will normally combine with the positively charged metal ions in the water adhering to the surface of the particles. Because of the effect of the Enzyme formulation in reducing the electric charge of the water molecule, there is sufficient negative charge to exert adequate pressure on the positively charged metal ions in the absorbed water film. As a result of this, the existing electrostatic potential barrier is broken. When this reaction occurs, the metal ions migrate into the free water, which can be washed out or removed by evaporation. Thus the film of absorbed water enveloping the particles is reduced. The particles thereby lose their swelling capacity and the soil as a whole acquires a friable structure.
- The hydrogen ions, which are liberated in the dissociation of the water molecules, can once again react with free hydroxyl ions and form water along the gaseous hydrogen. It is important to note that the moisture content of the soil affects the surface tension and is thus a factor affecting compaction. The Enzyme reduces surface tension making the soil compaction easier to perform. After the absorbed water is reduced, the soil particles tend to agglomerate and as a result of the relative movement between particles, the surface area is reduced and less absorbed water can be held, which in turn reduces the swelling capacity.

Field performance

- The Enzyme products have been used in more than 40 countries in the construction of structures from rural roads to highways for the past 30 years. A short review of some of the projects where Enzymes were used as a road stabilizer is presented below.
- A World Bank study on soil stabilization using Enzymes in Paraguay reported consistent road improvements and better performance from soil stabilizer treated roads compared to untreated roads. The conclusions were drawn based on data gathered on a large-scale study from multiple sites using commercial Enzymes and documentation of road performance for up to 33 months. Stabilization with Enzymes has been used in India. Good performance of these roads despite the heavy traffic and the high rainfall has been found. Besides an increase in the strength and durability of the roads, a reduction in project cost has also been achieved. Enzymes have been used successfully to stabilize roads in Malaysia, China and the Western USA at low cost. In Mendocino County, California Department of Transportation has conducted several tests of a compaction additive based on Enzymes. This natural product helped the road base to set very tightly, reducing

dust and improving chip-seal applications. With air quality and water quality agencies requiring dust reduction, this is a potentially effective new product, cheaper than asphalt. Emery County in Utah has more than 40 miles of surface-dressed roads treated with soil stabilization Enzymes that have been in use for several years. The climate is extremely arid and the 15 to 20% clay content in the aggregates has a very low Plasticity Index (PI) (<3%). A practical procedure for application of the treatment has been evolved. Jerome County in Idaho reported a similar experience. Two city streets in Stillwater, Oklahoma were also treated with Enzyme products. The clay had a plastic index of 20% and good performance was reported. A number of projects have been completed in Panaji (India) with the use of Enzymes. A rural road and a city road in Maharashtra have lasted for more than two years without any damage.

- Road sections placed in western Pennsylvania in the fall of 1992 passed subfreezing winters and over forty freeze-thaw cycles and required no maintenance for ruts, potholes or wash boarding during three years. The road sections then received chip-seal coats and asphalt surfaces with no requirement for repairs to the stabilized base. Enzymes have been used to stabilize more than 160 miles of subgrades and road surfacing in sites located across the National Forest land of the United States Department of Agriculture, where intense rainfall, highly erosive aggregate surfacing and expansive clay are found. The performance of the test sections shows improvement over non-stabilized control sections and historical performances of these sections before stabilization. Failures in the test sections have been related with the misuse of the Enzymes, such as application over the wrong type of soil and gradation.

Some of the properties modified by the stabilization process:

- Increased compressive strength: the Enzyme acts as a catalyst to accelerate and strengthen road material bonding. The Enzyme creates a denser, more cohesive and stable soil.
- Reduced compaction effort and improved soil workability: Lubricates the soil particles. This makes the soil easier to grade and allows the compactor to achieve targeted soil density with fewer passes.
- Increased soil density: Helps reduce voids between soil particles by altering electrochemical attraction in soil particles and releasing bound water. The result is a tighter, dryer, denser road foundation.
- Lowered water permeability: A tighter soil configuration reduces the migration of water that normally occurs in the voids between particles. It produces a greater resistance to water penetration deterioration.

Advantages of using Enzyme stabilizers instead of the traditional stabilizers:

- Environmentally safe: Enzymes are natural, safe (organic) materials. These materials are nontoxic and will cause no harm or danger to humans, animals, fish or vegetation.
- Cost effective: all-weather, low-maintenance soils for road construction can be achieved for a small fraction of bituminous paving or other resurfacing costs.
- Simple to use: the Enzyme is added to water, applied with a sprayer truck and mixed into the material. Normally the Enzyme comes in liquid concentrate. This benefit eases handling and preparation procedures and adds to the cost effectiveness.