Soil Stabilization
For
Road Construction
& Natural Liners

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Exclusively by:
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ENFRA, LLC
Presents
PERMA-ZYME™ USA

Perma-Zyme is a complex non-bacterial concentrated multi-enzymatic formulation that alters the properties of earth materials, providing one of the most cost-effective methods to stabilize roads and seal ponds and landfills.

WHAT IS PERMA-ZYME

Perma-Zyme is one of the world's finest products for road stabilization and pond and/or landfill sealing. Perma-Zyme is now available to the commercial and industrial marketplace. Perma-Zyme, a concentrated enzyme formulation, alters the properties of earth material to produce superior road base stabilization compared to all other road treatment materials now in use. Developed and proven through many years of field-testing, Perma-Zyme provides additional advantages to road builders, communities and the environment by being non-toxic, non-corrosive and totally biodegradable.

When mixed with water and applied prior to compaction, Perma-Zyme acts upon organic fines contained in the soil through a catalytic bonding process, producing a strong cementation action. Unlike inorganic or petroleum based products which temporarily hold soil materials together, Perma-Zyme causes the soil to bond during compaction into a dense permanent base which resists water penetration, weathering and wear. This process takes place in 72 hours under normal summer conditions.

In addition to creating a new and better way of building and maintaining roads, Perma-Zyme is being used successfully in the construction of lake beds, mine leach pads, ponds and landfill liners, wherever there is a need to increase the load-bearing capacity of the soil and to reduce the plasticity and permeability.

PERMA-ZYME'S ADVANTAGES

Perma-Zyme lowers the surface tension of water, which promotes fast and thorough penetration, and dispersal of moisture. This action causes hydrated clay particles to be pressed into and to fill the voids throughout the soil, thus forming a tight, dense permanent stratum. The increased lubricity of soil particles allows the designated soil density to be reached with less compaction effort.

Perma-Zyme reduces, by as much as 25%, the amount of water required to reach the optimum moisture level of the soil since it promotes rapid saturation and inhibits surface evaporation. The Perma-Zyme cementation action increases the soil bearing characteristics by promoting a closer binding of soil particles. This reduces the tendency of the soil to expand after compaction and results in a strong, stable earth layer. By achieving greater bonding density, soil materials resist migration of water. A properly treated Perma-Zyme base becomes almost impervious to water penetration and much more resistant to frost heaving.

Road builders can now construct a new road base using existing soil materials without trucking in additional aggregate (if sufficient fines are present). Mixing Perma-Zyme with the top 5 or 6 inches of soil will produce a road base that has more strength and less permeability than can be attained with any other treatment. If imported material is needed, less expensive, dirty aggregate is a requirement. The dirty fines are needed to bond the

material together. Dirty here means 12% to 24% cohesive fines passing a 200-mesh screen. The best part is that only 15 gallons of Perma-Zyme is needed to treat one mile of a 25-foot wide roadway (6 inches deep).

Perma-Zyme can be applied over a wide weather and locale range. From near freezing to hot summer days, from a rain forest to a desert, from lake bottom to an earthen dam, Perma-Zyme will provide superior results. New or existing roads treated with Perma-Zyme to the recommended depth will retain a tough, rupture-resistant surface that requires minimal maintenance, often requiring no additional "dressing" for a number of years.

Perma-Zyme is sold in liquid concentrate form. This eliminates the bulk storage, pre-mixing and handling of large amounts of materials. It will not corrode equipment. Perma-Zyme is non-toxic. It requires no special handling equipment and no special containment procedures as required with toxic and/or corrosive agents. It does not irritate skin tissue and causes no rashes or burns. Perma-Zyme contains no combustible materials, is non-explosive and can be used near open flames. It is non-gaseous and can be stored in poorly ventilated areas. It will not harm humans, animals, fish or vegetation under normal use and is totally biodegradable.

APPLICATIONS

ROAD BUILDING

Perma-Zyme is easy to apply and requires neither special equipment nor application procedures. It can be used with reclaiming machines or applied with regular road building machines. Perma-Zyme should be used with soils that contain approximately 18% cohesive fines. It is mixed with water used for compaction during normal road building techniques. A typical application to stabilize a 6-inch existing or new road base is presented as follows:

1. If the existing roadbed is too hard to blade, scarify to the required depth. Normally this should be done dry for better traction.

2. Add one gallon of Perma-Zyme concentrate to the required amount of water needed to bring 165 cubic yards of material up to optimum moisture. The amount of water needed will depend on how wet or dry your material is. A general starting rule for dry material is one gallon to 1,000 gallons water. With top loading water tanks, always fill the tank with water first, then add the Perma-Zyme. Failure to do this will result in a tank full of foam.

3. Spray the Perma-Zyme water solution over the road surface and start the blade mixing. Continue adding Perma-Zyme and water while mixing until the required amount of Perma-Zyme is distributed evenly throughout the material. During this time you should learn if the Perma-Zyme to water ratio should be changed. 15 gallons of Perma-Zyme will treat one mile 25 feet wide and 6 inches depth. If you misjudge the water and get the material too wet, blade to dry. If the material is too dry, add plain water. After thoroughly mixing, leave the soil material in a windrow overnight to promote total moisture absorption. We recommend this whenever possible for better compaction results with less effort.

4. If the road base is too dry the next morning, or after the material is thoroughly mixed and ready to lay, spray the surface with a Perma-Zyme water mixture of one gallon to 10,000 gallons water (approximately one pint to 1,200 gallons) before you pull it out of the windrow. Always start to lay the material on a damp floor. Pull the material out and lay in 2 or 3-inch lifts. Start compaction immediately, in sub-base fill, or pond areas, a sheepsfoot works fine, but usually a steel or pneumatic roller works best for finished roads. Continue compaction while you shape and dress the surface with a blade. Be sure to crown the surface to promote water drainage.

Even while laying and compacting, if your material dries too fast on a hot day, a light mist of Perma-Zyme treated water (1:10,000 gallons) can be applied. Continue to compact until the desired density is reached. Vibratory rollers may be used, but turn the vibrator off when finishing so that no fracturing occurs. The road is now ready for use. If you foresee heavy, high-speed traffic, involving spinning or skidding wheels, you might consider closing the road until the material has had a chance to cure for 2 or 3 days. Normal traffic will not harm it.

5. If an asphalt or other permanent wearing surface is to be added, a better bond can be obtained by moistening the surface with a spray of Perma-Zyme and water solution (1:10,000 gallons). This permanent surface can be applied at any time after a 3 to 5 day curing period under good weather conditions.

SEALING LAKES, PONDS OR LANDFILLS

For new construction, add Perma-Zyme to water as described above. The soil should ideally have approximately 25% to 30% cohesive, colloidal fines (200 mesh). Blade or disc the soil to blend in the Perma-Zyme and water, then grade and shape. Next compact the soil at optimum moisture using a compactor, tractor or truck. Generally the top 10 to 12 inches is treated for most liners.

When an existing pond or lake is filled with water and less than 8 feet in depth, use one gallon of Perma-Zyme for every 6,000 square feet of surface area (8 gallons per surface acre). Pour Perma-Zyme into the water from the windward side and around the perimeter, or across the surface if a boat or pump can be used. Stir up the silt from the bottom of the pond any way possible (dragging chains sometimes works). Fines placed into suspension together with the Perma-Zyme will then migrate to the seepage areas. Do not add water for 3 days. Perma-Zyme disperses clay and colloidal materials into the voids between each grain of soil and causes a catalytic bonding process, creating a strong, tightly compacted stratum that resists water penetration.

Success with this method will depend on the soil composition of your pond. If loss by seepage does not stop within 10 to 14 days, you can let the pond dry and re-treat using new pond construction methods described above. Perma-Zyme will not harm fish if used properly. It is most effective in sealing the soils in ponds when at least 25% of the material contains fines that will pass a 200-mesh screen, and the fines are primarily cohesive clays.

PERMA-ZYME

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PERMA – ZYME ADVANTAGES

1. **INCREASES SOIL DENSITY**. Perma-Zyme lowers the surface tension of water, which promotes fast and thorough penetration, and dispersal of moisture. This wetting action allows hydrated fine particles to be compacted closer and eliminates voids throughout the road base material, forming a tight, dense permanent stratum.

2. **REDUCES COMPACTION EFFORT**. The increased lubricity of soil particles allows the designated soil density to be reached with less compactive effort.

3. **REQUIRES LESS WATER**. Perma–Zyme reduces, by as much as 25%, the amount of water required to reach optimum moisture level of the soil due to rapid penetration of moisture and decreasing surface evaporation.

4. **BETTER LOAD BEARING CAPACITY**. Perma – Zyme treated material upon compaction creates a "cementation" action that signification increases the soil bearing characteristics by promoting binding of soil particles – giving a strong stable road base layer.

5. **LOWERS PERMEABILITY**. The binding of fines in the road base eliminates voids; decreasing the ability of water to migrate through the Perma-Zyme treated material. A properly treated road base using Perma-Zyme becomes almost impervious to water penetration and more resistant to frost heaving.

6. **MINIMIZES NEED FOR IMPORTING AGGREGATE**. Road base material using Perma-Zyme treatment can often be obtained from existing local soil materials that have sufficient cohesive non-granular fines. This minimizes importing additional aggregate. Mixing Perma-Zyme with the base material produces a road base that has more strength and less permeability than can be attained with any other treatment. Road base material with a higher "fines" content is preferable using Perma-Zyme. The "fines" act as bonding agents – filling voids and create a "cementacious" final product.

7. **COMPATIBILITY – WEATHER AND LOCATION**. Perma-Zyme can be applied under a wide variety of climates, during cool (above freezing) to hot summer temperatures.

8. **REDUCES MAINTENANCE AND LABOR**. New or existing roads treated with Perma-Zyme to the recommended depth will retain a tough, rupture-resistant surface that will require minimal maintenance; often requiring no additional dressing for a number of years.

9. **EASY TO STORE AND USE**. Perma-Zyme is sold in super concentrate form, eliminating bulk storage, premixing and handling of large amounts of material. It will not corrode equipment. Three 5 gal drums will treat 1 mile of road (6"depth by 25' wide).

10. **SAFE HANDLING NON-TOXIC NON-FLAMMABLE**. Perma-Zyme is non-toxic. No special handling or containment procedures are required. Perma-Zyme contains no combustible materials, is non-explosive and can be used near an open flame. It is non-gaseous and can be stored in poorly ventilated areas.

11. **ENVIRONMENTALLY SAFE**. Perma-Zyme will not harm humans, animals, fish or vegetation and is biodegradable.

12. Perma-Zyme has been manufactured for more than 30 years and is stabilizing roads throughout the world.

PERMA-ZYME

Perma-Zyme provides soil stabilization that enhances road construction and reduces repair and maintenance costs. It is also used in pond construction and other soil stabilization applications.

Perma-Zyme is an organic enzyme formulation designed to maximize compaction and increase the natural properties of soil to optimal conditions.

An enzyme is a natural organic compound similar to proteins, which act as a catalyst. Their large molecular structures contain active sites that assist molecular bonding and interaction.

Perma-Zyme's formulation increases the wetting action of water for increased penetration to assist compaction to obtain greater soil densities. Also, Perma-Zyme accelerates cohesive bonding of soil particles, creating a tight permanent stratum. Unlike inorganic or petroleum-based products with their temporary action, Perma-Zyme creates a dense and permanent base, which resists water penetration, weathering and wear. In normal road construction methods, compaction in the 90 percent range is normal. With Perma-Zyme, compaction from 98 percent up to 105 percent can be expected.

PERMA-ZYME IS USED IN CONCENTRATED FORM
MAKING IT VERY COST EFFECTIVE.

ONE GALLON OF PERMA-ZYME, WHEN ADDED TO THE REQUIRED AMOUNT OF WATER FOR COMPACTION, TREATS 165 CUBIC YARDS OF MATERIAL (1 LITER / 33 CU. METERS).

THREE 5 GALLON DRUMS OF PERMA-ZYME WILL TREAT ONE MILE OF ROADBASE 25 FEET WIDE AND 6 INCHES DEEP (APPROX 2 DRUMS PER KILOMETER).

Perma-Zyme is cost effective in both reducing construction costs as well & reducing long term road maintenance costs.

Since Perma-Zyme uses the non -granular, cohesive fines contained in the road base as a binder, a less expensive, higher 'fines' content base material may be used. Perma-Zyme saves you money in construction by allowing you to use available soil in the construction area instead of hauling in clean base.

Maintenance costs are greatly reduced since the cured Perma-Zyme base reduces moisture penetration into the road base. The increased density and reduced permeability significantly reduces wash boarding and rutting.

In addition to creating a new and better way of building and maintaining roads, Perma-Zyme is being used successfully in construction of lakebeds; mine leach pads, ponds, and other containment enclosures.

ROAD BUILDING WITH PERMA-ZYME

Road construction under optimum conditions should consider the following:

1. Use materials that are structurally sound. Road Base materials using Perma-Zyme should have a gradation mix (size distribution) that will result in good load bearing values and contain approximately 12% to 24% non-granular fines (-200 mesh size and be slightly cohesive in nature). Many roads have used material outside design standards. However, prior to construction field-testing was necessary for determining suitability, and upon completion excellent results were obtained. Some clays and 'fines' are silty in nature and are not useful for road construction. Also, excessive fines can cause problems as a result of high plasticity and or low bearing value.

2. Proper moisture must be maintained during compaction. Perma-Zyme works best between 2% - 3% below optimum moisture. Do not compact above optimum moisture. After applying Perma-Zyme to the road material, additional water can be applied to bring the moisture content closer to the amount needed for proper compaction.

3. Generally, roads should not be compacted in lifts greater than 3". Lift thickness is determined by the size and type of compaction equipment plus the type of material being compacted. Sufficient compactive effort must be maintained during road construction to obtain maximum density. Less compactive effort will be required using Perma-Zyme.

4. The road should be allowed to cure prior to use if possible (and final testing). However, the road can be used sooner if necessary. Drying of the base material will create decreased permeability and greater strength.

STEP 1. Blade or rip the existing road to a minimum depth of six inches and then stockpile the loose material (windrow or in-place). If the road requires greater depth, work the material in lifts. If additional aggregate is needed, use less expensive material (with more fines). Check the overall gradation of the material to insure it is within the design limits. Overall depth to be treated depends upon designed axle load requirements.

STEP 2. For each 165 cubic yards of road base material add one gallon of Perma-Zyme to the amount of water to obtain just below optimum moisture. Refer to the worksheet contained in this manual. Spray both the ripped surface and the stockpiled soil (windrow) to obtain optimum moisture. Blend the Perma-Zyme treated material using a grader blade or rotor-tiller/soil stabilizer machine, working the soil & aggregate back and forth to blend in the Perma-Zyme and water. If the material is too wet, blade dry; if too dry add water without Perma-Zyme to bring the material up to optimum moisture. After thoroughly mixing spread the material to grade. The road material can be left in a windrow over night to allow complete moisture absorption. This will result in better compaction with less effort.

STEP 3. Extend and crown the road surface with a blade. If your material dries out on a hot day, spray again with a dilute Perma-Zyme mixture. Compact with a compactor (minimum dynamic force of 10 tons) such as sheepsfoot or pneumatic roller. Vibratory rollers may be used for the first and second passes. However, further compaction should be done without vibrator action to avoid cracking. Compact in 3" or 8 cm lifts (layers) to insure maximum compaction.

After allowing the road surface to dry (cure), it is ready for use. If an asphalt or other road top surface is desired, better bonding will be achieved by moistening the surface with diluted application of Perma-Zyme and water at one to ten thousand (1:10,000) dilution rate. This surface application may be applied anytime after a three (3) day curing period (no rain).

PERMA-ZYME: WATER APPLICATION GUIDELINES (METRIC)
WATER TO BE ADDED TO REACH OPTIMUM MOISTURE FOR COMPACTION

IMPORTANT: DETERMINE APPROXIMATE MOISTURE IN SOIL BEFORE STARTING
Estimate Optimal Moisture then subtract existing moisture, to obtain water needed.

For example: FIELD CALCULATIONS ESTIMATED FOR ONE 8 cm LIFT

Volume	8 cm x 8 meters x 1,000 meters=	640 Cubic Meters
Material Weight	640 cu. meters x 1,600 kg/cu. meter =	1,024,000 kg or Liters
Additional water to achieve optimum moisture (8% moisture x 1,024,000 liters)		81,920 Liters-water
Safety Factor (avoids excess water) 70% x 81,920 liters =		57,344 Liters-water
Perma-Zyme – (1 Liter treats 33 cu. meters of soil) - liters required=		19 Liters PZ
640 cubic meters road base material divided by 33 Cu. meters		
Perma-Zyme dilution rate this example only (DRY CONDITIONS)		3,000 TO 1 Perma-Zyme

PERMA-ZYME DILUTION TABLE - Water to be added

WATER REQUIRED TO REACH OPTIMAL MOSITURE FOR COMPACTION

WATER %	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
WATER/LITER ***PZ***	528	1056	1584	2112	2640	3168	3696	4224	4752	5280 liters
USING 70% SAFETY	370	739	1109	1478	1848	2218	2587	2957	3326	3696 liters

PROCEDURE

1. DETERMINE (ESTIMATE) WATER TO BE ADDED TO SOIL THEN DETERMINE CAPACITY OF WATER TRUCK AND ADD PERMA-ZYME ACCORDING TO DILUTION RATE CALCULATION. (Estimate water slightly below amount needed)
2. APPLY WATER & PERMA-ZYME TO BASE MATERIAL, WETTING SURFACES EVENLY.
3. BLEND & MIX PERMA-ZYME & WATER INTO SOIL WITH GRADER BLADE OR STABILIZING MACHINE. SEVERAL PASSES MAY BE REQUIRED USING A BLADE.
4. OBSERVE IF ROAD BASE MATERIAL HAS ENOUGH MOISTURE FOR COMPACTION. (A HAND SAMPLE SHOULD MAKE A FIRM BALL)
5. IF MORE MOISTURE IS NEEDED, ADD PLAIN WATER AND RE-BLEND.
   DO NOT USE MORE WATER THAN IS NEEDED
6. COMPACT MATERIAL TO MAXIMUM DENSITY, USUALLY 5 TO 8 PASSES.
7. REPEAT THE ABOVE PROCEDURE FOR THE TOP LIFT (LAYER).
8. IF FIRST LIFT SURFACE IS TOO DRY, DAMPEN WITH A SMALL AMOUNT OF WATER. BEFORE 2nd LIFT IS EXTENDED ACROSS THE ROAD AND COMPACTED.

PERMA-ZYME: WATER APPLICATION GUIDELINES (ENGLISH)
WATER TO BE ADDED TO REACH OPTIMUM MOISTURE FOR COMPACTION

IMPORTANT: DETERMINE APPROXIMATE MOISTURE IN SOIL BEFORE STARTING
Estimate Optimal Moisture then subtract existing moisture to obtain water needed.

For example: FIELD CALCULATIONS ESTIMATED FOR ONE 3 INCH LIFT

Volume	3 in. x 24 feet x 5,280 ft. =	1173 Cubic Yards
Material Weight	1,173 cu. yd x 2,700 lbs/cu. yd =	3,167,100 lbs
Additional water to achieve optimum moisture (8% water)		30,404 gallons-water
Safety Factor (avoids excess water) 70% =		21,283 gallons-water
Perma-Zyme – (1 gal treats 165 cu. yds of soil) - gals required=		7.11 gals PZ
1,173 cubic yards road base material divided by 165 cubic yards		
Perma-Zyme dilution rate this example only (DRY CONDITIONS)		3,000 TO 1 Perma-Zyme

PERMA-ZYME DILUTION TABLE - Water to be added

WATER REQUIRED TO REACH OPTIMAL MOSITURE FOR COMPACTION

WATER %	1%	2%	3%	40/i	5%	6%	7%	8%	9%	10%
WATER/GAL ***PZ***	535	1070	1605	2140	2675	3210	3745	4280	4815	5350 gallons
USING 70% SAFETY	374	749	1124	1498	1873	2247	2622	2996	3371	3745 gallons

PROCEDURE

1. DETERMINE (ESTIMATE) WATER TO BE ADDED TO SOIL THEN DETERMINE CAPACITY OF WATER TRUCK AND ADD PERMA-ZYME ACCORDING TO DILUTION RATE CALCULATION. (Estimate water slightly below amount needed)
2. APPLY WATER & PERMA-ZYME TO BASE MATERIAL, WETTING SURFACES EVENLY.
3. BLEND & MIX PERMA-ZYME & WATER INTO SOIL WITH GRADER BLADE OR STABILIZING MACHINE. SEVERAL PASSES MAY BE REQUIRED USING A BLADE.
4. OBSERVE IF ROAD BASE MATERIAL HAS ENOUGH MOISTURE FOR COMPACTION. (A HAND SAMPLE SHOULD MAKE A FIRM BALL)
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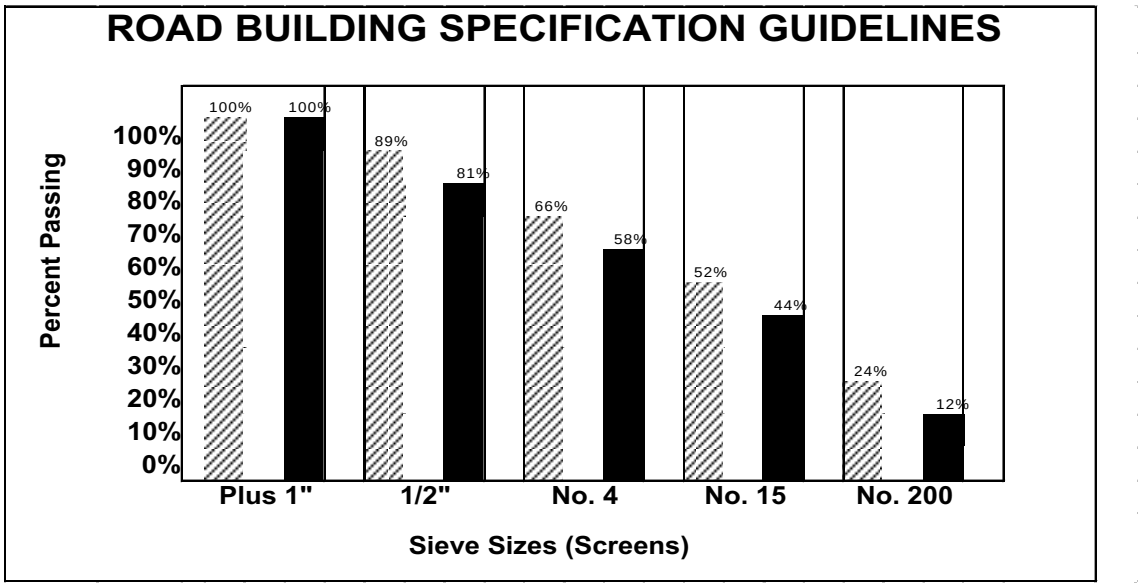


PERMA-ZYME GRADATION SPECIFICATIONS

SIEVE SIZE	GRADATION (% Passing)	GRADATION LIMITS UPPER	LOWER
1”	100%		
1/2”	85%	89%	81%
NO. 4	62%	66%	58%
NO. 16	48%	52%	44%
NO. 200	18%	24%	12%

PERMA-ZYME can be used effectively over a wide range of soil gradation mixes (aggregate sizes), as can be seen from the above chart.

To achieve effective stabilization, materials containing approximately 20% cohesive fines (non-granular) have been found a satisfactory target. However, excellent results have been achieved outside this range.

Additionally the soil should contain a wide range of material sizes to provide shear strength and internal friction, which increases load-bearing values.

Perma-Zyme has proven useful over a wide range of soil types. This range continues to expand Perma-Zyme is used in more diverse locations throughout the world.

MATERIAL GRADATION - refers to the distribution (% by weight) of the different sizes particles within a given soil sample. A sample is described as well - graded if it contains a good even distribution of particle sizes. If a soil sample is composed of predominantly one size particle it is said to be poorly graded. In terms of compaction, a well -graded soil will compact more easily than one that is poorly graded. Well-graded material allows smaller particles to fill the empty spaces between the larger particles, leaving fewer voids after compaction.

ROAD DESIGN

Construction of new and existing roads must consider several design elements, some of which are listed below:

1. *Traffic Loads (wheel weight and frequency of use)*
2. *Available road building materials*
3. *Topography and sub-base soil conditions (soft or firm)*
4. *Moisture (rain, snow and ground water)*
5. *Long Term Use and Maintenance requirements.*

The attached **"General Guidelines for Road Construction"** have been graphically depicted to show the required thickness to support different ranges on wheel loads.

Soft sub-base conditions require greater thickness - in some cases as high as 24 inches (60 cm.). Where the sub-base is firm a minimum thickness of 6 inches (15 *cm.)* can be used. Roads with truck traffic require greater thickness to support the high wheel loads of 20,000 lbs to 30,000 lbs **(**9,000 to 13,000 kilos). Analysis of the sub-base conditions and testing for load bearing capacity may he required to achieve proper design specifications

Traffic loads and speed also affect the life of a road. In many instances a hard 'wearing' surface cover is necessary. High-speed traffic increases the mechanical forces applied to the road surface. *To prevent surface wear face wear a protective cover such as asphalt, concrete or chip seal coat may be necessary.*

Surface and sub-surface moisture conditions also enter into the equation for good road design. It is important that the road has **adequate drainage** and that the sub-base and road base be kept as dry as possible to prevent structural failure. Side drainage channels are important as well as crowning of the road surface to allow water to flow away from the road surface. Where ground water is near the surface it may he necessary to place a rock sub-base or other engineered treatment. It is up to the engineer to evaluate these conditions.

Road building materials also affect the design of a road. The type and properties of the material greatly affect the performance of a road. *Well-graded gravel and soil* give maximum performance. *Cohesive fines* enhance the performance of a road (less rutting and pot-holes).

There are other factors, which must be considered. Civil Engineers qualified in road construction should be consulted for specific site conditions.

STRENGTH

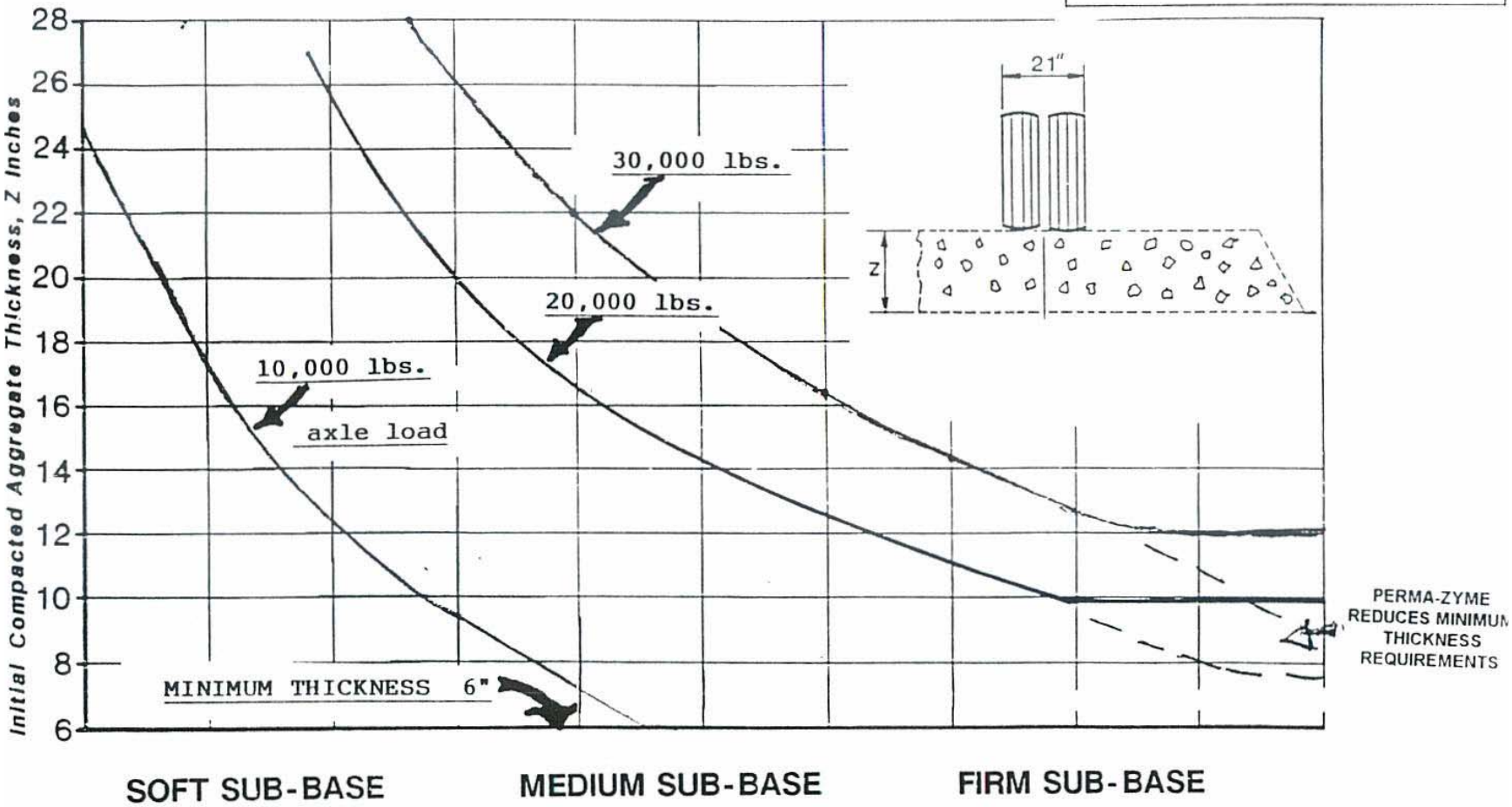
The load, which the wheel of the vehicle exerts on a gravel surfaces, spreads out as it passes down through the road base. The angle of force, increasing in width as it penetrates deeper into the road material is referred to as the internal angle of friction *0.* It varies depending upon the type of material present. The objective in road design is to have sufficient road base thickness to support anticipated wheel loads.

Perma-Zyme treated material has increased compressive strength which resists deformation and excessive flexing due to wheel loading. This stabilization results in an overall stronger road base. It also means less maintenance.

GENERAL GUIDELINES FOR ROAD CONSTRUCTION

Perma-zyme
will increase soil shear strength - reducing the overall required road base thickness .

DESIGN CURVES
WELL GRADED AGGREGATE OVER SOIL
ASSUMES TRUCK LOAD OF 10.00-20 TIRES ON DUAL WHEELS - SINGLE AXLE



QUESTIONS RELATING TO THE USE OF PERMA-ZYME

1. Is there any effect when Perma-Zyme is mixed with any other organic material (e.g. Ca0 or $CaC0_3$)?

Perma-Zyme works well with all organic soils. It will increase the bonding of the fines (-200 mesh) and allow greater moisture penetration to facilitate compaction. Perma-Zyme has been used successfully in roads containing Limestone (Ca0). Calcite ($CaC0_3$), a fine grain limestone or soft earthy clay, also reacts positively with Perma-Zyme. However, the use of clays should be minimized in road building - usually less than 24% - 200 mesh.

2. As time goes on will Perma-Zyme reduce or increase its bonding strength? Will the road come out with cracks or become fragile?

Perma- Zyme treated soils (for roads or ponds) achieve their greatest strength at the time of compaction and immediate subsequent curing (72 hours drying). Bonding of the soil particles takes place in the presence of moisture and compactive force. This condition will last as long as the material resists external forces. Heavy wheel loads, water, freeze-thaw cycles ultimately have an effect on all roads. Perma-Zyme treated soil resists these forces due to the bonded, high density of the road material. The road will resist the detrimental effects of erosion and mechanical forces.

Cracking occurs as a result of two factors: (1) if the road material contains a high percent of expansive clays - having a high shrink-swell factor. When the road is completed and dries out some cracking will appear. This reduces the effectiveness of the roads stability. However, we have seen roads showing this condition that have performed very well but with reduced life. (2) Soft sub-base may not support the treated base under wheel loads (i.e. expansive clays). The bearing capability of the road is insufficient. This is corrected by increasing the thickness of the road base.

When the Clay fines (minus 200 mesh) exceed 24% or are highly expansive some surface cracking will occur. Generally the cracks are superficial, often filling in with road particles during normal traffic use. Generally this condition is referred to as “Alligator Cracking” and does not significantly affect the stability of the road base.

Rain or other moisture will moderately swell the clay fines and the cracks will close. If the clay material is highly expansive, then the amount of fines should be kept low to reduce the amount of cracking.

Prior to placement of any surface material, the Perma-Zyme treated soil should be lightly sprayed with a dilute solution of water & Perma-Zyme to assist in the bonding of the new surface material (i.e. Asphalt) to the road base. Moisture will close many of the cracks.

Reflective cracks should not migrate upward through the asphalt, unless the clay fines are in the upper plasticity range and site conditions see radical sub-surface ground moisture variations.

Proper drainage will reduce ground moisture and keep cracking to a minimum.

3. After compaction, what is the ratio of expansion? Will extreme weather affect the road (hot or cold)?

After compaction, the expansion-contraction ratio will be dependent upon the soil type (percentage of expansive clays) as well as the gradation range (distribution of particle sizes). Well-graded soil (ranging from –200 mesh to 1 inch) is ideal for road building. The -200 mesh fines should be approximately 18%. If the frost level extends below the level of the road some heaving may occur, however in the spring the road should settle back to its original elevation without severe damage. Proper road construction including shoulder drainage will minimize the effects of frost. Good engineering practices should be observed. Hot weather does not affect a road, other than dry dirt surfaces tend to be dusty under high wheel loading. Perma-Zyme treated surfaces will reduce the amount of dust.

QUESTIONS RELATING TO THE USE OF PERMA-ZYME (Cont'd)

4. *When the road contains more than 20-30% clay, will the road surface become too slippery and lose traction?*

Road constructed with material containing a high clay contact will exhibit slippery surfaces when wet. It is necessary to use as much aggregate as possible to not only increase overall strength of the road and increase traction as well in wet conditions.

In many applications surface treatment is applied as part of the overall design. This provides a wearing surface for traction, moisture protection, and greater overall strength. Cost and availability of materials are the primary factors affecting the type of surface treatment, if any.

Perma-Zyme works well with soils that have a clay content passing a 200-mesh screen between 18% to 24%. This range of fines has been indicated as an acceptable range for road building material.

The State of California Transportation Dept. has tested Perma-Zyme (see Appendix II) in soil that has a high clay content and found approx. 27% increase in unconfined compressive strength using Perma-Zyme. The soil tested was substantial clay with over 95% passing a 200-mesh screen. The clay is classified as" FAT CLAY".

In road building it is desirable to minimize excessive clay content. Under moist conditions the surface will not have proper surface friction and excessive plasticity may be present.

Rex Funk, Emery County Road Supervisor, Utah has experience using Perma-Zyme for many years. He has reduced his road maintenance by 25%. For example, where a road typically required bimonthly grading activities, and periodic re-gravelling, he used Perma-Zyme to stabilize the road and then placed a thin "chip seal" over the surface. A portion of the road was left bare. Substantial cost savings were obtained and the bare section of road did not require any maintenance for over 16 months. This road is in a rural location in Emery County, however it receives a wide range of traffic.

5. How long will the roads last when used with Perma-Zyme?

Perma-Zyme treated roads have been in use for over 10 years without significant maintenance. The longevity of a road is a function of several factors:

a. Climatic conditions such as temperature ranges and rainfall.
b. Type of soils used in construction,
c. Road design - crowning, drainage & other engineered parameters
d. Type of vehicular traffic, speed and degree of usage.
e. Wearing surface applied (if any).
f. General maintenance - frequency and quality.

6. Can temporary roads be constructed using less Perma-Zyme?

Perma-Zyme should always be used at the rate of 1 gal per 165 cu yds or 1 liter per *33* cu meters of soil material. Temporary roads might be constructed with reduced thickness, providing the wheel loads would not immediately destroy the road.

7. What kind of equipment and method *of construction is used* to work *on pond slopes?*

Ponds are designed to engineered specifications, matching desired capacity with site topography, depth and with or without containment berms. Side slopes of the pond generally are designed with slopes not exceeding 3:1. Consideration is given to equipment capability during construction, potential wave erosion and general usage.

Ponds generally are constructed using water trucks, Bulldozers, Motor graders and usually sheepsfoot compactors (due to high clay content). Perimeter berms are compacted in lifts to rough dimensions and bladed to finish elevations. Sometimes a bulldozer is used for this work due to the steepness of the slope.

QUESTIONS RELATING TO THE USE OF PERMA-ZYME (Cont'd)

Various combinations of equipment are used in difficult ponds. A bulldozer pulling a sheepsfoot compaction drum, or a clamshell excavator being used for grading the side slopes. Equipment availability often dictates what is built in the field.

8. Is compaction required when using Perma Zyme?

Perma-Zyme is used when moisture is applied to soil for compaction to maximum density. Stability or stabilization occurs when soil particles are in close contact. Even when used in pond applications, the downward force of the water assists in compaction.

Spraying Perma-Zyme on soil without any compaction will not affect a change in erosion. The soils ability to resist erosion is a function of the mineral makeup of the soil and compaction (or density).

9. Will Perma-Zyme affect plant life if there is contact?

Perma-Zyme is not harmful to plant life in its full range of various applications, i.e. road building, pond construction, etc.

ASPHALT COVER OVER PERMA-ZYME BASE
* Chip Seal *

This is a general guideline discussion only. Refer to a qualified oil-asphalt representative for further information

Either Emulsion (CRS) or (MC) asphalt can be used. The emulsion means it is cut back or diluted with water and is shot at a temperature around 106° F. (71° C.). The MC is cut back with diesel fuel or other petroleum product and shot at temperatures of 225° F. (107° C.). The advantage of one over the other is debatable. Generally speaking the MC will penetrate dirty gravel better than emulsion, but may have a tendency to bleed off more if the balance of oil to gravel is not correct. When using MC, the first coat is thinner, usually MC-800, and the second coat heavier - MC-3000.

When using Emulsion, use the same weight, CRS - 2 for both layers. There are also available variations of CRS-2, some quick dry, some rubberized, some hard. Check with your supplier to see what is available in your area. Also, when using Emulsion, you need approximately 29% more material to obtain the same amount of asphalt thickness, due to drying where water evaporation reduces the overall weight.

The Perma-Zyme road surface should be prepared at least three (3) or more days prior to applying the asphalt. The surface should be smooth and dry hard surface. Dress any imperfections prior to applying the asphalt, as they will extend up through the finished surface (a smooth base is essential). *Prior to applying or shooting the first layer of oil, dampen the surface with a mist of Perma-Zyme treated water diluted 1gal of Perma-Zyme to 10,000 gallons of water. The Perma-Zyme mist will help the oil bond to the road surface*. After this dries or loses its sheen, you are ready to apply the oil. Usually approximately; *.4* to; .5 gallons of oil is applied per sq. yd. of surface. Then immediately apply 3/4 inch of 3/4' minus clean gravel and compact with compactor. After the first layer of oil and gravel is rolled down, you can pull a (non-rotating) drag broom over the surface to smooth out any roughness caused by the chip spreader, trucks or roller. This will insure a smooth surface for the second layer. Now the second (final) layer of; 0.35 to; 0.40 gallons per sq. yd. of oil and 1/2 inch of 1/2" or 3/8" chips can be laid down and compacted. The gravel chips must be fractured rock to stay in place. Pea-gravel cannot be used. If you have the proper amount of oil, gravel and chips, the oil should penetrate both layers and bond together. If too much oil is used, bleeding will occur. Insufficient oil will not allow proper bonding.

PLEASE NOTE: This is just a guideline. Different oils and gravels react differently. Consult your oil distributor representative for further information and recommendations.

HAUL ROAD STABILIZATION WITH PERMA-ZYME

Mine haul roads are often constructed with native site soils containing a wide gradation of materials. Often there is a high content of fines (-200 mesh), which in the past has caused stabilization problems. PERMA-ZYME assists in binding fines together with larger material into a dense well-compacted material having a high degree of stabilization, higher tensile strength than non-treated roads. Also, roads treated with PERMA-ZYME will resist water penetration. Benefits include: reduced maintenance and increased utilization of existing site materials.

PERMA-ZYME provides efficient use of water (easier penetration in the soil-base material), achievement of greater density after compaction, as well as an increase in tensile strength and unconfined compressive strength. Roads treated with PERMA-ZYME will also have less dusting than non-treated roads.

ROAD CONSTRUCTION

One gallon of PERMA-ZYME will treat 165 cu. yds of road base material. It is added to the water truck and sprayed onto the material prior to compaction. Depending upon the specific type of soil, PERMA-ZYME is diluted into approx. 4,000 gallons of water (the amount of water required to obtain optimum moisture for compaction of 165 cu yds. of material).

The water to PERMA-ZYME ratio will vary, depending upon site conditions and existing moisture in the base material.

Construction of the road should be done in lifts not greater than 6" - and depending upon the type of compaction equipment, it is recommended that 3" or 8cm lifts are used, thereby insuring proper compaction. Attention should be given to the moisture content and blending for maximum distribution of PERMA-ZYME throughout the road material.

PERMA-ZYME is used for some dust control applications. It is applied at a dilution rate of 10,000 gallons of water to 1 gallon of PERMA-ZYME. This has been effective in reducing dust and decreasing the total amount of water required for dust control.

NEW POND CONSTRUCTION

Soil used for pond construction should have at least 30% *passing a 200-mesh screen and be non-granular cohesive clays*. Soil liner thickness varies depending upon soil type and permeability. Typical Specifications for soils containing clay-like and colloidal material are:

Sieve Size (Screen)	Percent Passing	Percent Retained
No.4	95%	5%
No. 60	85%	10%
No. 200	30%	55%
No. 200 minus		30%
		100%

Gravel - granular material should he kept to a minimum. For best results the soil should be analyzed by a laboratory to see if it is suitable for pond construction or if additional materials, such as clays or bentonites, are needed.

One gallon of PERMA-ZYME treats 165 cu. yards (1 liter / 33 cu. meters) of material. Perma-Zyme is added to water used to bring the soil to optimum moisture content for compaction. If possible the soil should be bladed to the side and the sub-base compacted to provide sub-base strength. Then soil should be brought across the pond bottom in approximate 6" (15 cm) lifts. The soil material should be bladed or disced to obtain uniform moisture content. It is suggested that the pond liner be placed in lifts not greater than 6" (15 cm) each. Upon blending the water and PERMA-ZYME into the soil, grade and shape the pond. Compact with a sheepsfoot to achieve maximum soil density. *Proper compactive effort is essential for best results (low permeability)*. Soils having heavy clay content will require "sheepsfoot" compaction.

Additional lifts can be put in place as required, using the same procedure. Between lifts moisten the surface with a dilute solution of PERMA-ZYME (10,000:1) prior to placing an additional lift of soil on top. Then compact as required.

Soil material can be treated in place at the pond location or prepared off-site and transported to the pond site with moisture and PERMA-ZYME already mixed in. Then the material should be bladed to the required thickness, contoured and compacted to a finished surface.

EXISTING PONDS

If the pond has evidence of seepage, PERMA-ZYME can be used to reduce and/or eliminate water loss. Apply PERMA-ZYME to the surface at the rate of 8 gals PERMA-ZYME per surface acre (70 liters/hectare). Apply the PERMA-ZYME across the pond surface (if a boat can be used) and/or around the entire pond perimeter to assist in complete dispersion.

If possible, stir up the pond bottom by dragging chains across. Fines placed into suspension, together with PERMA-ZYME, will then migrate to the seepage areas and seal off the problem area.

If the seepage is due to excessive granular material on the pond bottom, bentonite or clays may have to be added along with PERMA-ZYME to help seal the voids. A reduction of seepage should be visible after 72 hours.

Dry ponds can be reconditioned using the same procedure for new construction.

PERMA-ZYME

CONSTRUCTION OF SANITARY LANDFILLS, WASTE CONTAINMENT STRUCTURES, SEWAGE, AND LIQUID CONTAINMENT

Soil Stabilization, Construction Techniques & Materials are the major components of at type of containment structure (Pond or Landfill). Perma-Zyme contributes significantly to the construction of containment structures. Natural clay liners are geologically stable and have longer projected life expectancy than most man-made materials. Clay liners are self-healing when put under stress. Perma-Zyme works well with clay soils to assist in compaction and density. It also enhances cohesiveness & binding of soil particles.

The complexity of containment structures and ponds is influenced by:

A. Geographic Location

B. Site Topography

C. Rainfall

D. Ground Water Conditions

E. Soil Conditions

i.e. bearing values, expansive nature, permeability, subsidence danger, frost, etc.

F. Type of material to be contained

Water/other solutions; Combination liquid-solid materials Mixture of inorganic and organic wastes;

Anticipated level of toxicity.

Engineers use well-defined specifications in their design of containment structures. The design and supervision insures that a proper liner has been installed and that it will meet the intended use over a specified time. Installation costs also play an important role in design. Use of soil-clay liners has been very cost effective, as well as meeting long term design standards.

Several construction methods & materials are used in containment structures & ponds. Liner materials include: Natural clay & soil, Synthetic Liners, Soil Cement, among others.

IMPORTANT ELEMENTS TO CONSIDER:

- Type of construction (equipment & installation expertise)
- Construction supervision and testing.
- How carefully will material be placed over the liner?
- What stresses will the liner material see over time?
- What unplanned event can occur to breach the liner's integrity causing cracks, punctures or other liner breach?
- What is the life expectancy of the liner material - as in the case of synthetic liners and what substances might be present to degrade the synthetic material in the future.

PERMA-ZYME - WHERE IT CAN HELP IN CONTAINMENT STRUCTURES.

Common elements in all containment structures include: Soil Stabilization and Construction Techniques - Materials.

Whether a natural soil liner or synthetic liner is used, the underlying surface must be stabilized prior to placing the liner on top. This is an area where Perma-Zyme can be very effective. It will assist in compaction, producing greater soil strengths, as well as reducing permeability. Once the material has been treated and compacted, it is in a long-term natural state, which will resist degradation.

Perma-Zyme has been specified by engineers for use in construction of a natural soil liner (clay type with low permeability). Perma-Zyme increases soil density and decreases permeability. Construction includes compacting the material in 6" (15 cm) lifts using proper compaction equipment and the correct amount or moisture to obtain maximum density. Perma-Zyme is a non-toxic biocatalytic multiple enzyme product. The technology of Perma-Zyme's biochemistry is proteinaceous and enzymatic in nature. It has been used for over 30 years.

For Waste Containment or Landfill construction, Perma-Zyme is used to assist in compacting clay containing soil into a containment barrier that will meet regulatory requirements. Common to all systems of constructing waste containment structures, testing and special analysis involving soil type and characteristics are required.

When site and pond size have been specified, soil core samples are taken for laboratory analysis. The tests will include particle size determination using ASTM-D-422 Method, as well as a hydrometer test without Perma-Zyme to demonstrate the condition of the soil clay content. Laboratory permeability tests must then be run on soil samples with and without the appropriate Perma-Zyme treatment. Tests should be conducted over a range of densities so compaction requirements may be specified. If soil tests show a two-micron clay content of less than 20%, it's often necessary to use borrow-soil to achieve an adequate clay concentration with the in-situ soil.

The pond excavation can be achieved with standard earth-moving equipment used in any standard pond construction. The low permeability soil liner mixed and treated with Perma-Zyme is to be compacted in 6" (15 cm) layers. Total thickness is specified by the desired permeability coefficient. The loss rate for a field liner can be predicted from laboratory data using the following (The actual mathematics are best left to a qualified engineer).

DARCY'S LAW

$$Q = -A * k * s$$

Q = flow rate, (ft^3/d, m^3/d)
A = cross-sectional area (ft^2, m^2)
k = permeability coefficient under unit gradient, (ft/d, m/d)
s = hydraulic gradient (dh/dl, ft/ft, m/m)

PERMA-ZYME - WHERE IT CAN HELP IN CONTAINMENT STRUCTURES. (Cont'd)

Each layer (6" or 15-centimeter thickness) is mechanically mixed, adding water and Perma-Zyme as required. One gallon of PERMA-ZYME treats 165 cubic yards of material, which is diluted with sufficient water to bring the soil-clay material close to optimum moisture. This mixing may be done off-site or in place, which ever is more suitable. Uniform mixing can be obtained by discing with an offset disc to a depth of 6 inches (15 centimeters) or by other approved mixing methods such as a blade pulverizer, or other means available. During compaction Perma-Zyme provides several beneficial functions. It "wets" the clay particles, thus permitting a higher compaction density [98 to 103% of optimum density (ASTM-D-698)]. The macromolecules in the PERMA-ZYME product provide a "surfactant-like" property, which aids dispersion of soil particles and provides certain "cementation" effects.

After mixing, the material is spread over the subgrade, or previously, completed layer, to the required depth to yield a 15 - centimeter compacted layer. Each layer is compacted to at least 95% as determined by AASHTO Method T-99. The density is verified with a nuclear moisture-density meter or other laboratory test method. Compaction is achieved with a sheepsfoot roller and the surface is worked to a smooth finish with a rubber tire or smooth steel wheeled roller. The final grade should be within 1 inch or 3 centimeters.

Upon completion of a layer of liner material, successive layers are installed by the same procedure. Immediately prior to spreading the treated material, the subgrade or the previous compacted layer should be kept moist to provide bonding between layers.

Upon completion of the top layer, the liner is ready for use. Throughout construction of the liner there is no concern about punctures as in the case of synthetic liners. Also the liner has been stabilized to the surrounding soil and is monolithic - able to withstand a variety of environmental conditions - temperature, settlement and load stresses. There is usually no overburden protective layer required, as in the case of a synthetic plastic liner.

FORCES THAT PLAY A ROLE IN ROAD CONSTRUCTION, DESIGN AND MAINTENANCE

MOVEMENT

Aggregate will move under wheel loading. If such movement is not prevented, deformation or rutting of the roadbed structure will result. Consider repeated wheel loadings from passing vehicles. The load from the wheel is transmitted to the aggregate or gravel, which transmits the load down to the subgrade. This downward force tends to move the aggregate and subgrade in the downward direction. As the granular material penetrates the soil, the soil is displaced. The displaced soil particles move to the point of least resistance, which is determined by several factors:

- Natural restraints imposed by the geometry of the road system.
- The plastic flow mechanism of the particular soil type.

Frequently, particles move to the point of least resistance - upward into voids or spaces between granular materials. This results in a loss of bearing capacity and a deformation or rut of the surface. With movement of fine soil particles within the aggregate, they add a lubricating effect on the aggregate, which further adds to deformation.

PERMA-ZYME treated road base, which by design has approximately 18% cohesive fines, is compacted into a dense, high strength material. This minimizes void or air space between the aggregate. The resulting increased density eliminates movement of soil particles within the road base material. Perma-Zyme treated material also binds together the soil particles - creating greater strength.

MOISTURE

Roads experience cycles of moisture penetration. Rain and surface water is driven down into the road base, both by pounding rainfall and by gravity. Water is also driven up through the road base by evaporation, transpiration and pumping. The number of cycles depends on the amount and frequency of the precipitation, the amount of heat on the road surface, which draws moisture and aids evaporation, and the number and, type of wheel loads. Moisture movement carries, smaller grained soil particles, which contaminates the structural integrity of the road base. As previously discussed, this causes rutting and surface deformation.

PERMA-ZYME treated road base, with increased density and cohesion of smaller soil particles, resists the penetration of moisture and eliminates the ability of soil particles to migrate within the road material. The reduction of moisture decreases the plasticity of the material - reducing road deformation under wheel loads.

STRENGTH

The load which the wheel of the vehicle exerts on a gravel surfaces spreads out as it passes down through the road base. The angle of force, increasing in width as it penetrates deeper into the road material is referred to as the internal angle of friction *0.* It varies depending upon the type of material present. The objective in road design is to have sufficient road base thickness to support anticipated wheel loads.

Perma-Zyme treated material has increased compressive strength which resists deformation and excessive flexing due to wheel loading. This stabilization results in an overall stronger road base. It also means less maintenance.

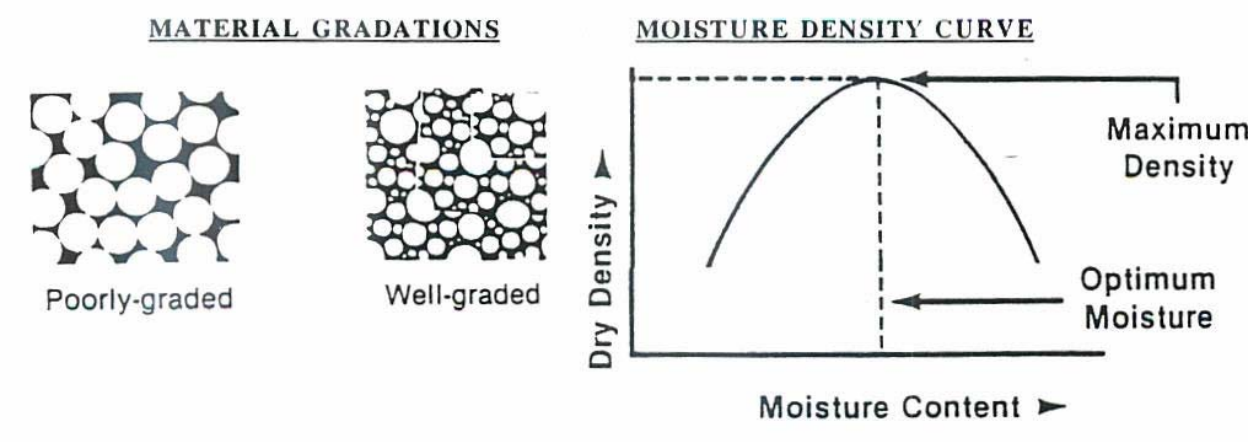
SOIL COMPACTION FUNDAMENTALS

COMPACTION is the process of physically densifying or packing the soil resulting in an increase in weight per unit volume. It is generally accepted that the strength of a soil can be increased by densification. Three important factors affect compaction:

Material Gradation
Moisture Content
Compactive Effort

MATERIAL GRADATION - refers to the distribution *(%* by weight) of the different sizes of particles within a given soil sample. A sample is described as well-graded if it contains a good, even distribution of particle sizes. If a soil sample is composed of predominantly one size particle, it is said to be poorly-graded. In terms of compaction, a well-graded soil will compact more easily than one that is poorly-graded. In well-graded material the smaller particles tend to fill the empty spaces between the larger particles, leaving fewer voids after compaction. This is further supplemented by using Perma-Zyme in the water during compaction.

MOISTURE CONTENT - or the amount of water present in a soil, is very important to compaction. Water lubricates soil particles thus helping them slide into the densest position. The wetting action of Perm-Zyme further enhances this action during compaction. Water and Perma- Zyme's enzymes also assists clay particle bonding, giving cohesive materials their "sticky' qualities. Proper compaction cannot be achieved in materials that are too wet or too dry. Engineers have determined that in almost all soil there is an amount of water, called optimum moisture content, at which it is possible to obtain maximum density with a given amount of compactive effort. The curve below shows this relationship between soil dry density and moisture content. It is called compaction curve, moisture-density curve or Proctor curve.



COMPACTIVE EFFORT - refers to the methods a compactor imparts energy into the soil to achieve compaction. Compactors use one or more types of compactive effort:

- Static weight (pressure) such as a drum or pneumatic roller
- Kneading action (or manipulation) sheeps-foot roller
- Impact (or sharp blow)
- Vibration (or shaking) vibrating roller

APPROXIMATE MATERIAL WEIGHTS

MATERIAL	WEIGHT lbs/yd^3	WEIGHT kg/m^3
Clay, dry excavated	1,847 lbs.	1,089 kg
Clay, wet excavated	3,080 lbs	1,826 kg
Clay and Gravel (dry)	2,700 lbs	1,602 kg
Clay and Gravel (wet)	3,085 lbs	1,826 kg
Gravel Dry (1/4 - 2”)	2,835 lbs	1,682 kg
Gravel, Sand & Clay loose	2,700 lbs	1,602 kg
Sand, dry loose	2,700 lbs	1,602 kg
Sand, slightly damp	3,240 lbs	1,922 kg
Sand & Gravel, dry	2,916 lbs	1,730 kg

NOTE: The above weights may vary in accordance with moisture content, texture etc.

PERMA-ZYME LAB TESTING (METRIC)

CONCENTRATE

THE FOLLOWING HAS BEEN PREPARED TO DETERMINE THE AMOUNT OF PERMA-ZYME TO BE DILUTED WITH WATER FOR SOIL TESTING.

A. CALCULATE THE WEIGHT OF SOIL PER M^3	**_____kg**	**1,602 kg**
B. DETERMINE OPTIMUM AMOUNT OF MOISTURE FOR COMPACTION	**_____%**	**10%**
C. WATER REQ'D PER M^3	**_____kg**	**160kg**
D. PERMA-ZYME APPLICATION RATE (M^3 PER LITER)	**___33__M^3**	**33 M^3**
E. AMOUNT OF WATER PER LITER PERMA-ZYME (C X D)	**_____liters**	**5,280 liters**
AMT PERMA-ZYME PER LITER OF WATER (1.0/E)	**_____cc**	**0.2 cc**

IF THE WEIGHT OF THE SOIL IS LESS, THEN THE AMOUNT OF PERMA-ZYNE PER LITER OF WATER WILL INCREASE PROPORTIONATELY.

When testing for unconfined compressive strength the sample should be dried in *an oven at* 35^0 *to* 40^0 *C. for 72 hours.*

SPECIFICATIONS

(AGENCY NAME)

(PROJECT NAME)

Note: This specification was written from specs used by various Road Districts.

SECTION 305 - ENZYME TREATED BASE COURSE

305.1 - DESCRIPTION: This item shall consist of construction of a base course composed of a mixture of mineral aggregate, enzyme, and water, and placed on a prepared subgrade or base, in conformance with the lines, grades and dimensions shown on the plans or established by the Engineer and in accordance with these specifications and manufacturer's recommendations.

305.2 - MATERIALS:

305.2.1 - MINERAL AGGREGATE

Mineral Aggregate shall conform to the following specifications:

1. That portion of aggregate passing the No. 40 sieve shall be slightly plastic (1 **< P1 <** 6) when tested in accordance with AASHTO Designation T-90.

2. The dry mineral aggregate shall be uniformly graded within the gradation specified in Subsection 305.3.1 when tested in accordance with AASHTO Designation T-27. When a specific gradation is designated non other shall be used unless authorized in writing by the Engineer.

   The total amount of material, passing the #200 sieve shall be determined by washing in water in accordance with AASHTO Designation T-11.

305.2.2 - ENZYME: The enzyme shall be PERMA-ZYME or equivalent and supplied by the contractor.

305.2.3 - WATER: Water for mixing and processing shall conform to the requirements of Subsection 505.2.4.1.

SPECIAL PROVISION SECTION 305 - ENZYME TREATED BASE COURSE

305.3 - CONSTRUCTION REQUIREMENTS:

395.3.1 - INITIAL GRADATION:

305.3.1.1: The Contractor shall initiate production operations using ideal gradations and tolerances listed in Table 305.3. When material conforming to gradations listed in Table 305.3 is produced, the Contractor shall supply the Engineer with three (3) cubic feet of material for suitability testing.

TABLE 305.3 - INITIAL TARGET GRACATIONS

SIEVE SIZE	IDEAL GRADATION (Percent Passing)	IDEAL GRADATION TOLERANCE
1”	100%	0
1/2”	85%	+/-4%
NO. 4	62%	+/-4%
NO. 16	48%	+/-4%
NO. 200	18%	+/-6%

305.3.1 The Engineer shall have five (5) working days to perform suitability tests. If the material is found to be suitable, the Contractor shall perform crushing operations as described in Subsection *305.3.2.* If the material is found to be unsuitable, the Contractor shall make adjustments in the material as directed by the Engineer. Adjustments may include but not limited to increasing colloidal fines, reducing the amount of material passing the #200 sieve. The revised material shall be submitted for retesting.

305.3.2 FINAL GRADATION: After the suitability of the material has been established and an ideal gradation range has been determined, the Contractor shall submit, in writing, the gradation to the Engineer for his approval. The job-mix gradation shall have definite single values for the percentage of aggregate passing each specified sieve based on the dry weight of the aggregate.

Acceptance of aggregates with respect to gradation shall be based on the average of the samples taken from the lot. When the daily quantity exceeds 1,500 tons, a minimum of four samples shall be required. Acceptance shall be in accordance with Table 305.3.

Test samples for acceptance shall be obtained and submitted by the Contractor under the supervision of the Engineer from the windrow immediately prior to processing.

The samples shall be chosen on a random basis. In addition, the samples shall be distributed as uniformly as possible in time throughout the test lot so as to be representative of the material being produced.

In addition to the random acceptance samples from each lot, the Engineer may require samples of the enzyme treated base course from any portion of the course that exhibits non-uniform appearance. The Engineer may reject this material when test results show deviation from the job-mix gradation.

SPECIAL PROVISION SECTION 305 - ENZYME TREATED BASE COURSE

305.3.3 - PROPORTIONING, MIXING, AND PLACING: The subgrade on which the base course placed shall be uniformly shaped and firmly compacted. If the required compacted completed depth of the base course exceeds 3 inches, the base shall be placed in two or more layers of approximately equal depth with no layer exceeding 3 inches.

The base course material shall be placed on the subgrade in a uniform windrow or spread to a uniform thickness in sufficient quantity to obtain the required compacted thickness. The specified enzyme/water mixture (1 gallon enzyme per 165 cubic yards of base course) shall be applied and spread uniformly to the aggregate after which the base course shall be thoroughly mixed by a traveling mixing plant, motor grader, or other approved equipment. Mixing shall be continued until the material is uniform in appearance, texture, moisture content and free from pockets of segregated aggregate. If additional enzyme/water is needed, the material shall be mixed before the liquid is added. During mixing, water shall be added in the amount necessary to permit the material to ship freely from the blade of the mixing equipment. At a minimum this is anticipated to be near optimum moisture.

Material that inadvertently becomes too wet shall be bladed until dry enough to place in the windrow. Then the material shall be uniformly spread over the subgrade to the required lines and grades. The treated base course material shall be spread and compacted to required density. When additional water is needed to bring the material to required moisture content for compaction and performance, the Contractor shall add a mixture of 1 part enzyme concentrate to 10,000 parts water to the base course material without damaging the road.

For the final lift, the Engineer shall establish one set of references at reasonable intervals on centerline and both shoulders not to exceed 100 feet for line and grade control of placing operations. The Contractor shall furnish, place, and maintain such supports, wire, devices, and materials as may be required to provide continuous line and grade.

305.3.4 - COMPACTION: After the enzyme treated mixture has been spread, it shall be longitudinally rolled, beginning at the outside or lower side and proceeding toward the higher side. Each pass of the roller shall overlap the preceding pass by at least one-half the width of the roller. A vibratory roller may be used for the first and second pass, but the vibrator shall be turned off for additional passes to prevent fracturing of the material. The percentage of moisture in the base mixture during compaction shall not be below nor more than two percentage points above optimum moisture content as determined in the laboratory, unless otherwise directed by the Engineer.

The method of compaction and acceptance with respect to density shall be as specified in Section #_____.

305.3.5 - FINISHING: The surface of the compacted roadbed material shall be brought compliance with the lines and grades shown on the plans and typical sections. Surface ridges and irregularities shall be trimmed by means of a motor grader. Trimming shall be done in such a manner as to avoid loosening of the material. Additional rolling of trimmed subgrade shall be performed if ordered by the Engineer.

305.3.6 - WEATHER LIMITATIONS: Enzyme treated base shall not be mixed or placed while the temperature of the roadbed or in the shade is below 40° degrees Fahrenheit or when conditions indicate the temperature may fall below 30° F. within twenty-four hours. Enzyme treated base shall not be placed on frozen subgrade or mixed when the aggregate is frozen.

SPECIAL PROVISION SECTION 305 - ENZYME TREATED BASE COURSE

305.3.7 - MAINTENANCE: The Contractor shall maintain, at his expense, the base course in acceptable condition until all work is completed and the final surface course has been placed. Maintenance shall include the repair of defects or damaged areas.

Repairs of faulty or damaged work shall be performed through full depth of the lift. Adding a thin (1 gallon enzyme to 10,000 gallons of water) application of the enzyme mixture and reworking the lift shall be permitted so long as adequate performance of the course is achieved.

305.4 - METHOD OF MEASUREMENT

305.4.1 - Enzyme treated base course shall be measured by cubic yard of material in place on the roadway.

305.4.2 - No separate measurement shall be made for water.

305 - BASIS OF PAYMENT

305.5.1 - Enzyme treated Base Course: The accepted quantity of this item shall be paid at the contract unit price, which includes all equipment, materials, and labor necessary to crush, place, process, compact, and complete the item in its final accepted state.

PERMA-ZYME

CHARACTERISTICS & OPERATING PARAMETERS

CHARACTERISTICS

PERMA-ZYME IS A HIGHLY CONCENTRATED
PRODUCT FORMULATED TO CONTAIN AN ENZYME
BASE WITH A DISPERSANT IN A WATER BASE SOLUTION

NON-TOXIC, NON-HAZARDOUS & NON-FLAMMABLE

SHELF LIFE – 10 YEARS, STORE BELOW 120 F. (49 C.)
FREEZNG IS NOT HARMFUL

OPERATING PARAMETERS

PERMA-ZYME SHOULD NOT BE DILUTED LESS THAN 1 PART PERMA-ZYME TO 500 PARTS WATER. THIS WILL INSURE SUFFICIENT WATER FOR PERMA-ZYME TO PENETRATE EVENLY THROUGHOUT THE SOIL.

TOTAL MOISTURE SHOULD NEVER EXCEED OPTIMUM MOISTURE.

ROAD CONSTRUCTION SHOULD NOT BE DONE WHEN RAIN IS EXPECTED.

SOILS WITH HIGH MOISTURE CONTENT PROHIBIT PENETRATION OF PERMA-ZYME INTO THE SOIL.

THE CONCEPT IS “NEVER EXCEED” OPTIMUM MOISTURE. IT IS HARD TO DRY OUT WET SOIL!

WORK WHEN DAYTIME TEMPERATURE IS ABOVE 40° F (10 C.) AND NIGHTTIME TEMPERATURE IS ABOVE FREEZING 32° F (0 C).

MATERIAL SAFETY DATA SHEET: Perma-Zyme

ENFRA LLC
Perma-Zyme USA
4081 East La Palma Ave., Suite A
Anaheim, CA 92780 USA
Tel: 714-237-1180 Fax: 714-630-5221
charbon@pacbell.net

Version: No. 5450
Issue Date June 1998
Supersedes Any Previous Versions

FOR 24-HOUR EMERGENCY, CALL 714-237-1180 (USA)

PRODUCT IDENTIFICATION

Product:	Perma-Zyme
CAS Number:	None Listed
Dangerous Goods Class:	Non-Hazardous

Hazard Rating (NFPA/HMIS)
Health = 0* Reactivity = 0
Fire = 0 Special = None

Rating Scale
0 = minimal 1 = slight
2 = moderate 3 = serious
4 = severe

*Mild eye irritant, non-mutagenic and non-carcinogenic. None of the ingredients in Perma-Zyme are regulated nor listed as potential cancer agents by Federal OSHA, NTP or IARC.

Use: A water-based non-hazardous and environmentally friendly enzyme liquid used for soil stabilization.

SAFE HANDLING INFORMATION

Fire/Explosion Hazard
Treat the same as water.

Reactivity Data
Perma-Zyme is very stable. Avoid high temperatures, as this will neutralize the enzymes. Avoid low or high pH substances (i.e., acids, caustics). Perma-Zyme is compatible with most compounds. It will not polymerize or create hazardous byproducts. There are no specific conditions to avoid.

Storage and Transport
No special precautions are required. This product is non-hazardous for storage and transport according to the U.S. Department of Transportation Regulations.

Perma-Zyme requires no special labeling or placarding to meet U.S. Department of Transportation requirements.

Spills and Disposal
Spill or Leakage Procedures: Recover usable material by convenient method; residual may be removed by wiping with absorbent material or wet mop. If necessary, unrecoverable material may be washed down to a sanitary drain with large amounts of water.

Waste Disposal: Perma-Zyme is water soluble and biodegradable and will not harm sewage-treatment microorganisms if disposal by sewer or drain is necessary. Dispose of in accordance with all applicable local, state and federal laws.

PRECAUTIONS FOR USE

Exposure Limits
Perma-Zyme presents no health hazards to the user, other than mild eye irritancy.

Ventilation
No special ventilation is required during normal use.

Personal Protection
Precautionary Measures: No special requirements under normal use conditions, with the exception that eye protection is recommended during the handling of undiluted product.

Eye Protection: Caution, including reasonable eye protection, should always be used to avoid eye contact where splashing or exposure to concentrated product may occur.

Skin Protection: No special precautions required. Rinse completely from skin with water after contact.

Respiratory Protection: No special precautions required.

Work and Hygienic Practices: Wash or rinse hands before touching eyes or contact lenses. Follow standard hygienic practices for handling cleaning agents.

Symptoms of Overexposure and First Aid Treatment
Eye Contact: Reddening may develop. Immediately rinse the eye with large quantities of cool water. Continue 10-15 minutes or until material has been removed. Be sure to remove contact lenses, if present, and lift upper and lower lids during rinsing. Get medical attention if irritation persists.

Skin Contact: Minimal effects, if any. Rinse skin with water. Rinse shoes and launder clothing before reuse.

Swallowing: Essentially non-toxic. Product may cause a slight laxative condition. Give several glasses of water to dilute if swallowed. Do not induce vomiting. If stomach upset persists, consult a physician.

Inhalation: Non-toxic. Prolonged exposure to product in a mist form (not recommended) could cause a mild irritation of the nasal passages and throat. Remove to get fresh air. Get medical attention if irritation persists.

INGREDIENT INFORMATION

Perma-Zyme contains no hazardous constituents. Its principal ingredients are miscellaneous enzymes produced from food products. Perma-Zyme contains no known USEPA priority-pollutants, heavy metals or chemicals listed under RCRA, CERCLA, or CWA.

TOXICITY INFORMATION

Human Health Effects or Risks from Exposure
Adverse effects on human health are not expected from Perma-Zyme, based on the ingredients. Perma-Zyme is a mild eye irritant. Mucous membranes may become irritated if concentrate is inhaled.

Medical Conditions Aggravated by Exposure
No aggravation of existing medical conditions is expected.

Non-Human Toxicity
Acute Mortality Studies:

Oral LD50 (rats): #1 toxicity (death by drowning)
LC50 (brine shrimp): > 100 mg/l

Dermal Irritation: Dermal sensitivity tests on guinea pigs proved not sensitizing.

Eye Irritation: Mild irritation was noted in white rabbits without rinsing with water. Irritation scores in rabbits at 24 hours did not exceed 15 (mild irritant) on a scale of 110.

BIODEGRADABILITY AND ENVIRONMENTAL

Biodegradability:
Perma-Zyme is readily decomposed by naturally occurring microorganisms.

Environmental Toxicity Information:
Perma-Zyme is nontoxic to marine and estuarine test animals at concentrations less than 2,100 mg/l (2.10%).

OTHER INFORMATION

Physical Description and Properties: PERMA-ZYME
Appearance/Odor: Brownish liquid with slight sweet odor.
Boiling Point: 212 Degrees F (100 Degrees C).
Flashpoint: Not Applicable.
Specific Gravity: 1.07 @ 25 Degrees C.
Flammability Limits: Not Applicable.
Freezing Point: 0^0 C.
Vapor Pressure: Not Applicable.
Solubility in Water: Complete.
Volatile Organic Compounds: None

General Information:
Containers: Perma-Zyme residues can be removed by rinsing with water. The container may be recycled or applied for other uses.

NOTICE

All information appearing herein is based on data obtained by the manufacturer and recognized technical sources. Judgments as to the suitability of information herein for purchaser's purposes are necessarily the purchaser's responsibility. Therefore, although reasonable care has been taken in the preparation of this information, Enfra, LLC or its distributors extends no warranties, makes no representations and assumes no responsibility as to the suitability of such information for application to the purchaser's intended purposes or for the consequences of its use.

TEST METHOD FOR PREPARING AND ANALYZING PAVEMENT SUBGRADE, SUBBASE AND BASE/COURSE MATERIALS CONTAINING PERMA-ZYME* IN A MATERIALS TESTING LABORATORY

This test method protocol has been developed in response to requests for proper laboratory procedures when testing road base materials treated with **Perma-Zyme***[1]. It should be noted that no laboratory sample will simulate the actual strength characteristics exhibited in the field with full-scale Perma-Zyme treated base materials. Therefore, if one is to obtain a truly valid approximation of the relative strength of treated material, it is recommended to test Perma-Zyme treated road base by obtaining fully cured samples from actual roadbeds. Test methods described below will reference the American Society for Testing and Materials (ASTM) and the American Association of State Highway and Transportation Officials (AASHTO in parentheses). Test methods may be found at the ASTM Internet site: http://www.astm.org, and the AASHTO Materials Book (http://www.transportation.org).

PREPARATION OF LABORATORY SAMPLE

Prior to any laboratory testing, a suitable sample must be prepared. It is recommended to prepare a minimum soil/aggregate mix of five (5) gallons (18.9 liters). All (100%) mineral aggregate must be crushed (e.g., cracked rock faces). That portion of aggregate passing the No. 4 sieve should be slightly plastic (1<PI<6) when tested in accordance with ASTM Method D4318-95a (AASHTO T90-00). Any humus material and/or other organic material (i.e., roots, moss, leaves, etc.) should be removed from the test material. The dry mineral soil/aggregate material should be uniformly graded with the gradations specified in Table 1, following ASTM Method C136-96a (AASHTO T88-00).

TABLE 1 - INITIAL TARGET GRADATIONS

Sieve Size	Ideal Gradation (Percent Passing)	Ideal Gradation Tolerance
1"	100	0
_"	85	±4
No. 4	62	±4
No. 16	48	±4
No.200	18	±6

[1] *Perma-Zyme is a proprietary enzyme product manufactured exclusively by International Enzymes, Inc.

DETERMINATION OF OPTIMUM MOISTURE

After properly preparing the laboratory sample as described above, optimum moisture should be determined using the modified R. R. Proctor test, as described in ASTM Method D698-91, Procedure C (AASHTO T265-93, 2000).

PREPARATION OF SAMPLE FOR PERMA-ZYME ADDITION AND CURING

Once the optimum moisture is determined for the proper mix design, a 6-inch (152.4 mm) diameter mold should be prepared, as described in ASTM Method D698-91, Procedure C (AASHTO T265-93, 2000). Prior to placing the mix in the mold, the 5-gallon bucket of mix should be brought to one percent below optimum moisture (Optimum Moisture - 1%) using water and Perma-Zyme. Perma-Zyme should be added at a rate of 0.004 fluid ounces per gallon aggregate mix, or 0.02 fluid ounces (0.6 milliliters) per 5-gallon (18.9 liters) bucket (see following comment note). This is based on the fact that one gallon of Perma-Zyme will stabilize 165 cubic yards of road base material (0.03 ounce per cubic foot). The contents of the bucket should be thoroughly mixed and then rechecked for moisture content prior to compaction and curing. It is recommended to cover the bucket with a leak-proof lid to avoid moisture loss during sample preparation.

NOTE: Since it is so difficult to mix such a minor amount of Perma-Zyme for even a 5-gallon sample mix, it is recommended to first calculate the necessary water needed to bring the 5-gallon sample up to the proper moisture content, as described above (e.g., optimum moisture - 1%). Dry the prepared aggregate/soil mix to minimize the moisture content. Then pre-measure the calculated amount of water in a graduated container. Add the calculated amount of Perma-Zyme (0.004 fluid ounces per gallon aggregate) to the water and mix gently. Then use this Perma-Zyme/water solution to bring the 5-gallon sample up to the proper moisture content.

With the prepared moisture adjusted Perma-Zyme/aggregate mix, a 6-inch mold should be prepared in accordance with ASTM Method D698-91, Procedure C (AASHTO T193-99). It is suggested that each of the three specified layers to be compacted be an approximate one-inch (25.4 mm) layer or lift. Once the mix has been properly compacted using Procedure C, the sample should be carefully removed from the mold and placed on a drying rack.

The compacted sample should then be cured for a minimum of 72 hours at room temperature. If possible, curing time should be increased to 120 hours (5 days) prior to any strength testing to allow for maximum bonding strength. If it is desired to use a curing oven, the oven temperature should not exceed 98 Degrees Fahrenheit (37 Degrees Celsius).

STRENGTH TESTING OF LABORATORY SAMPLE

If desired, the fully cured Perma-Zyme/aggregate mix sample can be tested for relative strength. The recommended strength test is ASTM Method D1883-94, California Bearing Ratio (AASHTO T193-99). Since a 6-inch mold is specified, the prepared and cured sample should simply be carefully reinserted into the mold cylinder for testing. While the stated CBR test can be conducted on a soaked or unsoaked sample, it is recommended to conduct the test on the “dry” or unsoaked basis for better reliability and repeatability of results.