

PRODUCT EVALUATION: PRESTO ROADBASE SAND CONFINEMENT GRID

FINAL REPORT

by

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Abstract:

The Alaska Department of Transportation and Public Facilities is continuously looking for methods of using marginal soils for roadway and airport embankments. In areas such as the Western coast of Alaska, where quality materials must be imported and therefore are prohibitively expensive, the use of native soils represents a significant cost savings to the State.

The Army Corps of Engineer Experimental Waterways Station has developed a method of stabilizing sand using a plastic grid system. This report analyzes the system for use in Western Alaska using a finite element analysis and the Chev5L computer program. These analysis indicate that the grid system is at least equal to 6 inches of crushed aggregate. The bearing capacity of the sand is greatly enhanced since lateral displacement is eliminated.

Although additional work is still required, it is expected that the sand grid system discussed in this report will ultimately result in a significant cost savings in embankment construction in Western Alaska.

IMPLEMENTATION

The sand grid system discussed in this report is being strongly considered for use in the construction of the airport at Shishmaref. The performance of the system has been quite good in several military installations in Florida, Mississippi and Virginia. However, its use under Arctic conditions is essentially untested.

Sand is a non-frost susceptible material. The grids would therefore be expected to perform similarly to installations in warmer climates. It is recommended that a test be constructed and monitored. If the grids perform well, they should be considered for use whenever well graded gravel is not readily available. Of course, the final decision should be based upon economic considerations and good engineering judgement.

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SYMBOLS, SUBSCRIPTS AND TERMS USED IN THIS REPORT

SYMBOLS

G	-	Stress
τ	-	Shear stress
δ	-	Strain
C	-	Cohesion
C_i	-	Cohesion of layer i
H_i	-	Thickness of layer i
γ	-	Dry density
ϕ	-	Angle of internal friction
B	-	Footing width
E	-	Modulus of elasticity

SUBSCRIPTS

x, y	-	Horizontal axes for analysis
z	-	Vertical axis
r	-	Radial
U	-	Ultimate

TERMS

Sand	-	Fine aggregate. Unified Soil Classification (USC) System defines this as material passing the No. 4 sieve and retained on No. 200 sieve.
Gravel or Aggregate	-	Terms are used interchangeably to denote high quality natural or crushed rock for pavement construction purposes. USC System defines this as material smaller than 3" and retained on No. 4 sieve.

PRODUCT EVALUATION: PRESTO ROADBASE SAND CONFINEMENT GRID

INTRODUCTION

Extensive full-scale testing of the trafficability of confined beach sand pavement layers has been carried out by the U.S. Army Corps of Engineers at their Waterways Experiment Station (WES) in Vicksburg, Mississippi. Confinement is achieved using a honeycomb type of grid cell structure developed by the Corps and constructed of various materials (1,2). Initial material types included paper and aluminum, with the current, and apparently most successful, confinement grids consisting of polyethylene (HDPE) produced and marketed by Presto Products (PTY) Ltd. The experimental work by the Corps has as its primary objective the determination of structural adequacy of pavements for temporary facilities. However, there are apparent advantages in using the sand confinement approach in permanent installations, as base or subbase layers, where suitable aggregate material is not available, or costly to obtain. This situation exists particularly in Western Alaska where often the only construction material that is readily available is sand, and aggregate, if used, is imported at a high cost. The alternative to imported material is the use of sand stabilized with asphalt. This usually provides the surfacing layer. Use of the Presto plastic sand confinement grid may provide an economically attractive alternative as the base or subbase layers for a pavement structure in this area. The objective of this evaluation is to make a first estimate of the effect of including Presto confinement grids in a sand base course subject to high wheel loads and to evaluate three possible idealized pavement alternatives. No thermal effects are considered.

PRESTO ROADBASE GRID INFORMATION (4)

MATERIAL: HDPE

YOUNG'S MODULES (E): Approximately 100,000 psi

ULTIMATE STRENGTH

AND ASSOCIATED STRAIN:

	σ_u (psi)	ϵ (%)
Machine direction (i.e., in direction of extrusion)	3650	455
Transverse direction (i.e., normal to extrusion direction)	3605	238

EXPANDED PANEL SIZE: 8 ft x 20.5 ft x 8 in

SHEETS OF HDPE/PANEL: 60

NO. OF CELLS/PANEL: 561

APPROX. CELL AREA (EXPANDED): 0.274 ft

HDPE THICKNESS: 0.055 in.

SHIPPING WEIGHT/PANEL: 122 lb.

PAVEMENT LOAD INFORMATION:

Based on possible use of the Presto grid at Shishmaref Airport, the analysis was performed assuming that the design aircraft is a Lockheed L-382 Hercules with the following parameters:

Maximum Takeoff Gross Weight (TOGW) = 255,000 lbs.

Assumed tire pressure = 100 psi

Wheel load : Federal Aviation Administration (FAA) recommends assumption that 95% of load carried by main gear, hence,

$$\begin{aligned} \text{wheel load} &= \frac{.95 \times 155,000}{4} \\ &= 36,800 \text{ lb.} \end{aligned}$$

$$\text{Contact area} = \frac{36,000 \text{ lb}}{100 \text{ psi}} = 368 \text{ in}^2$$

Equivalent circular contact area has radius $R = 10.82$ in.
or Elliptical contact area : See Figure 1.

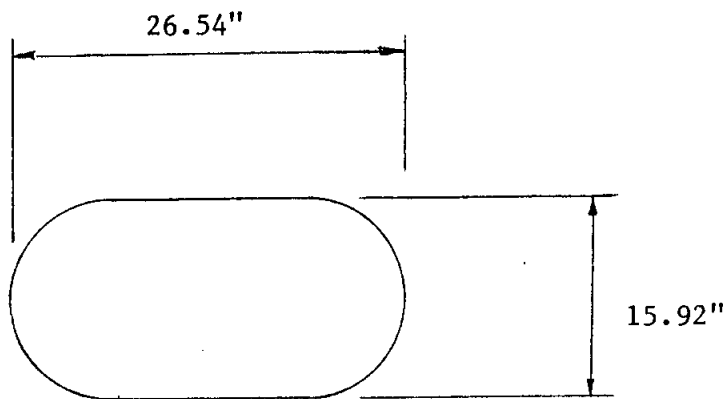


Figure 1. Elliptical contact area.

ANALYTICAL APPROACHES

Mitchell, et al, (3), have analyzed various possible failure modes of a grid confinement system. However, most of the work was related to model test results and modes of confinement cell failure that, although important, do not provide an estimate of relative performance of confined systems to unconfined materials, in pavement service. At the time that these analyses were performed, three dimensional finite element simulation of the confined system was not feasible due to computer constraints in terms of time and cost. Current computer abilities have reduced the extent of these constraints, and one of the analysis techniques used in this evaluation involves a simplistic three dimensional finite element analysis of the proposed pavement structure. There can be little question that such a three dimensional finite element analysis is probably the only technique currently available that can adequately model the confined sand pavement structure if sufficient detail is employed. A simpler approach is to use elastic layered pavement analysis programs. This necessitates assumptions regarding the distribution and position of the confining material (plastic) as a horizontal elastic layer within the pavement structure, which has been performed for this evaluation using the CHEVN program (10). Assuming a horizontal elastic layer configuration for the grid is similar to the methods of analysis typically used for evaluating the effect of layer reinforcement using engineering fabrics, which cannot carry compressive forces (6,7). A third technique involves application of bearing capacity analysis as used in classical soil mechanics, with the inclusion of an "apparent cohesion" for the sand based on the plastic grid tensile and shear properties. It should be pointed out that neither the finite element nor the elastic layer analysis has the ability to directly model the major effect of the confining materials, namely that it allows the confined layer to carry tensile stresses. This is critical in terms of pavement materials since typical unbound pavement materials cannot withstand even small tensile stresses. As a first approximation to the behavior of the confined system, it is suggested that the analysis be carried out assuming elastic behavior of all materials in tension and compression and that, if tensile stresses develop in the confined layer, such stresses are transferred to the confining grid material. If the tensile stresses carried by the grid do not exceed its ultimate strength, and the strain incompatibility resulting from the stress transfer is acceptable, then the pavement is acceptable. If not, a modification would be required.

In comparison, the unbound material (i.e., no confinement system) is assumed to be inadequate whenever it is required to carry tension. At this juncture three points can be made regarding a confined sand system:

- i) In considering the compressive behavior of the confined material under load, bearing capacity theory will be used assuming an apparent cohesion for the layer based on grid properties. This gives an estimate of improvement in bearing ability of the material due to the grid confinement, and probably gives a reasonable approximation to actual material response in bearing. For instance, this theory shows significant increases in bearing capacity using the Presto grid material.

ii) Tensile behavior of pavement layer materials is of paramount importance since many typical materials exhibit zero tensile strength. Finite element or elastic layer analysis assume the material behaves equally elastic in tension or compression and provide techniques for stress-strain estimation. The point to be made is that, in pavements, load associated tension only becomes significant if the pavement is subject to bending, i.e., the subgrade must have a lower modulus of elasticity than the pavement layer materials.

iii) If no bending occurs, bending tension does not develop and the effect of the grid in allowing the confined layer to carry tension is incorporated into the bearing capacity analysis by using an apparent cohesion. The unconfined layer can usually carry compressive forces adequately if a bearing failure is inhibited, e.g., by a competent surfacing layer.

BEARING CAPACITY ANALYSIS (5)

A critical consideration in estimating bearing capacities of soil is the cohesion, C. For the material (sand) at Shishmareff C = 0, i.e., it is cohesionless and has a maximum dry density $\gamma = 110$ pcf (11). A value of $\phi = 30^\circ$ can be assumed, but an estimate of the apparent cohesion provided by including the Presto grid is necessary.

i) Consider area of plastic grid in horizontal shear. Sixty (60) sheets, each .055" thick and 11 feet long make up an expanded 8' x 20' panel, i.e., there are three 11 ft. long sheets per foot length of panel with plane area subject to horizontal shear equalling $3 \times .055 \times 11 \times 12$ or 21.78 in. This is for an 8 foot width, so for one square foot of confined material there is $\frac{21.78}{8} = 2.7225$ in.² of plastic.

ii) Consider area of plastic in tension :

A one foot section (8" deep) has $3 \times .055 \times 8 = 1.32$ in.² of plastic.

Thus, if for HDPE, σ_U (tension) = 150 psi, then

$$C = \frac{150 \times 1.32 \text{ lb}}{8/12 \times 1 \text{ ft}^2} = 297 \text{ psf}$$

or, if, $\tau_U = 100$ psi

$$\text{then } C = \frac{100 \times 1.7225}{1 \times 1} = 272.25 \text{ psf.}$$

(NOTE: Low values of σ_U , τ_U for HDPE are used to ensure that strain levels in the confined layer are reasonable.)

For the bearing capacity analyses, use C = 270 psf or .27 ksf and $\gamma = 110$ pcf

TERZAGHI ANALYSIS

For a circular load on the surface, the Terzaghi bearing capacity equation reduces to (using $\phi = 30^\circ$ and $\gamma = 110$ pc).

$$q_U = 48.36 C + 5.918 \text{ ksf, and, without the plastic grid (C = 0)}$$

$$\begin{aligned} q_U &= 0 + 5.91 \times 110 = 0.65 \text{ ksf} \\ &= 4.5 \text{ psi} \longrightarrow \end{aligned}$$

while, if the grid is included, with $C = .27$ ksf

$$\begin{aligned} q_U &= 48.36 \times .27 + 5.91 \times 110 = 13.71 \text{ ksf} \\ &= 95.2 \text{ psi} \longrightarrow \end{aligned}$$

MEYERHOF ANALYSIS

The Meyerhof equation reduces to, for the same assumptions as above:

$$q_U = 48.224 C + 1.17\gamma \text{ ksf}$$

$$C = 0, \text{ i.e., no grid}$$

$$\begin{aligned} q_U &= 1.17 \times .11 = 0.129 \text{ ksf} \\ &= 0.9 \text{ psi} \longrightarrow \end{aligned}$$

$$C = .27 \text{ ksf, i.e., with grid}$$

$$\begin{aligned} q_U &= 48.224 \times .27 + 0.129 = 13.15 \text{ ksf} \\ &= 91.3 \text{ psi} \longrightarrow \end{aligned}$$

HANSEN ANALYSIS

The Hansen equation becomes :

$$q_U = 48.525C + 4.521\gamma$$

$$C = 0, \text{ i.e. no grid}$$

$$\begin{aligned} q_U &= 4.521 \times .110 = 0.497 \text{ ksf} \\ &= 3.5 \text{ psi} \longrightarrow \end{aligned}$$

$$C = .27 \text{ ksf, i.e. with grid}$$

$$\begin{aligned} q_U &= 48.525 \times .27 + .497 = 13.60 \text{ ksf} \\ &= 94.4 \text{ psi} \longrightarrow \end{aligned}$$

The preceding estimates are based on the assumption that the apparent cohesion is applicable everywhere below the applied load. In fact, the grid layer is only eight (8) inches deep so the apparent cohesion value should be modified. Bowles (5) suggests that an average value be used up to a depth of about $0.5 B \tan (45 + \phi/2)$.

For Shishmaref, $B = 2 \times \text{load radius} = 1.8$ feet.

Therefore: $0.5 B \tan (45 + \phi/2) = 1.6$ feet and the suggested average cohesion $C_{\text{avc}} = \frac{\sum C_i H_i}{\sum H_i}$ to a depth $= 0.5 B \tan (45 + \phi/2)$

$$\text{i.e., } C_{\text{ave}} = \frac{0.27 \times (8/12) + 0 \times (1.6 - 8/12)}{1.6} = 0.113 \text{ ksf.}$$

Using this value for the apparent cohesion of the system in the previous equations (noting that the unreinforced case is unchanged), the following is obtained for the confined case:

Terzaghi:	q_U	= 6.12 ksf	
		= 42.5 psi	—————>
Meyerhof	q_U	= 5.58 ksf	
		= 38.8 psi	—————>
Hansen	q_U	= 5.99 ksf	
		= 41.6 psi	—————>

Thus, bearing capacity analysis indicates an improvement from an average estimated bearing value of 3 psi for the unreinforced case to an average value of 41 psi for the case where an eight (8) inch confinement layer is used. Although the improvement is dramatic, it is not adequate to accommodate the 100 psi contact pressure of the design aircraft without increasing the thickness of the confined layer, or placing a surfacing layer over the top of the confined layer.

FINITE ELEMENT ANALYSIS

The 8-node solid brick element of the finite element program SAP (8) was used to model the idealized confined layer material, while the confining grid was represented as truss elements, with stiffness but no area, placed between the solid elements and linking the element nodes. Symmetry was used to reduce the size of modelled pavement segment. The surface area of grid per cell was used to calculate an effective side of approximately six (6) inches for simulation as a square grid (plan view). The 6 x 6 inch plan dimension was used throughout for the brick element, but thickness varied from two (2) inches at the surface to six (6) inches at a depth of 26 inches. This is a very crude mesh for the brick element, and, in retrospect, a finer mesh should have been used since the 8-node brick does not handle bending very well. It is proposed that this effect be investigated at a later date, as well as comparing the results with those using a 17-to 21-node thick shell element. However, the 8-node element results, although crude, do give an idea of the effect of including the confining grid. It should be noted again that the analysis cannot take into account the fact that sand in the grid does not carry tension, so that any sand tensile stresses are transferred to grid elements for the confined material.

Contact pressure used for the finite element analysis was 130 psi to maintain a constant wheel load, since the modelled geometry, i.e. 6" x 6" squares, does not simulate the estimated elliptical contact area of Figure 1 accurately.

The pavement structure was idealized as shown in Figure 2. Note that the analyses did not attempt to simulate the effect of the asphalt penetration layer normally used to seal the top of the grids.

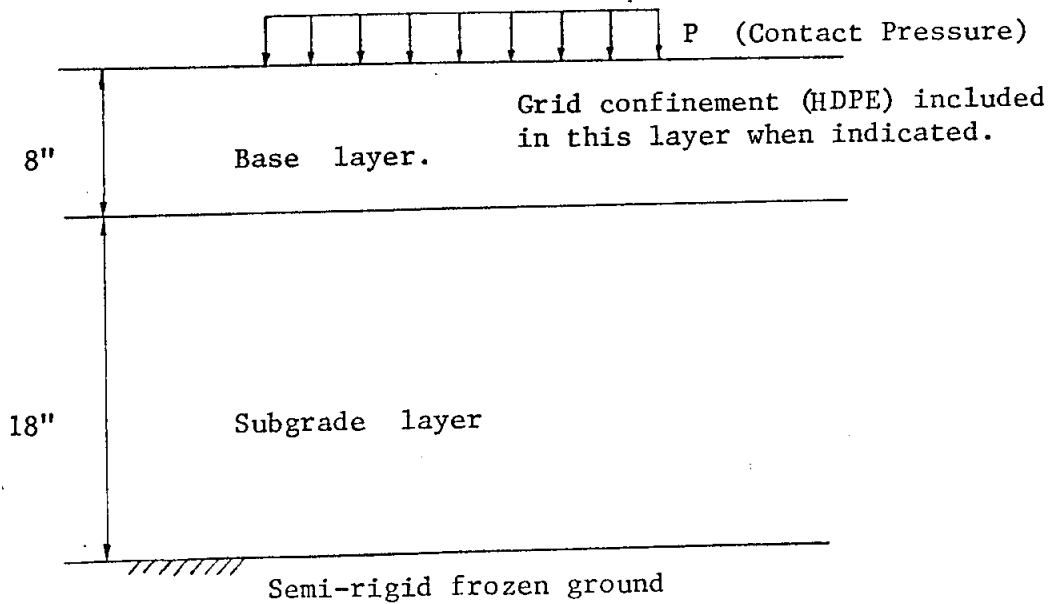


Figure 2. Idealized pavement structure for SAP analysis.

Materials characteristics were assumed as follows (from References 1,4, 9, 10,11):

	Grid	Confined	Subgrade	Frozen Ground
Young's Modulus E (psi)	100,000	20,000	varies	rigid
Poisson's Ratio	0.3	0.4	0.4	---

Subgrade modulus was varied from 20,000 psi to 5,000 psi to simulate varying in situ moisture contents and drainage characteristics, and the system was analyzed for the case where confinement was included in the base layer as well as with an unconfined base layer. Results of the analyses are plotted in Figures 3 and 4. Figure 3 shows the variation of horizontal stresses at the bottom of the base layer for both confined and unconfined cases, and the vertical stress on top of the subgrade layer for both cases. It can be seen that, due to the low volume of high modulus material (i.e., HDPE) in the confined layer, there is little difference in the idealized elastic behavior of the confined or unconfined systems. Both systems develop tension at the underside of the base layer at approximately the same subgrade modulus value for the case being analysed. However, the unconfined base layer does not have the ability to carry any tensile stress so that this represents a failure condition. On the other hand, the confined layer can withstand tension in the grid, so the tensile stresses are transferred from the sand phase to the grid, i.e., it is assumed that the worst case likely to develop is zero horizontal stress in the sand. The grid stresses are plotted on Figure 4, both as calculated by SAP and the increased value due to load transfer. If this mechanism occurs, then theoretically, the confined grid system fails only when the HDPE materials ultimate tensile strength is exceeded. As can be seen from Figure 3, for the case analysed, the tensile grid stresses reach a value of about 1,500 psi which is less than the approximately 3,500 psi yield strength of HDPE indicated by Presto. However, in practice, transferring stresses to the grid from the soil results in incompatible strains at the grid/sand interface and the HDPE strain at a tensile stress of 1,500 psi may be such as to effectively represent a pavement failure condition. This should be investigated further, but as a first approximation to grid performance, the above approach is probably acceptable.

NOTE: From Figure 3 the pavement structure is inadequate in terms of commonly accepted allowable subgrade vertical strains.

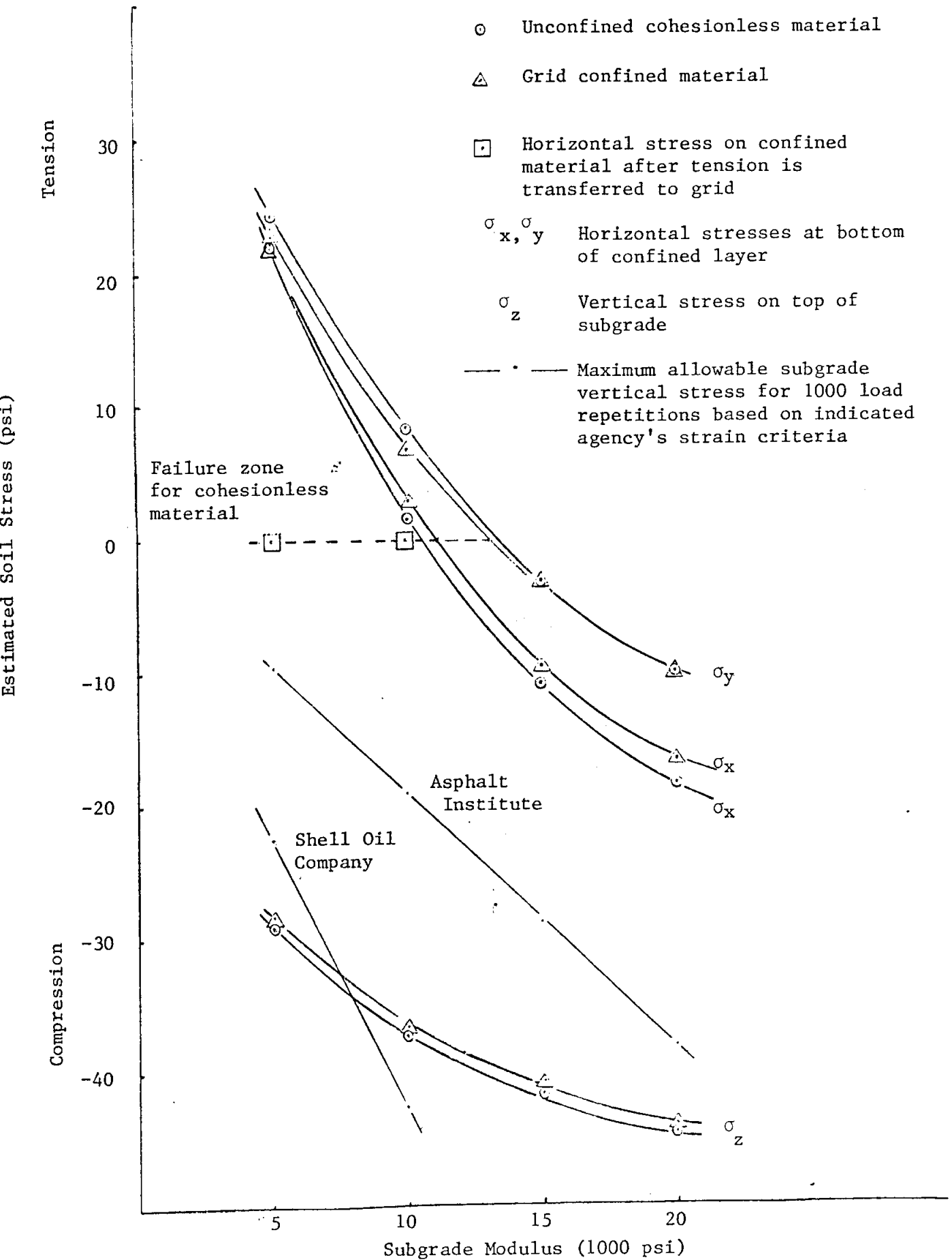


Figure 3 Stresses from SAP finite element analysis.

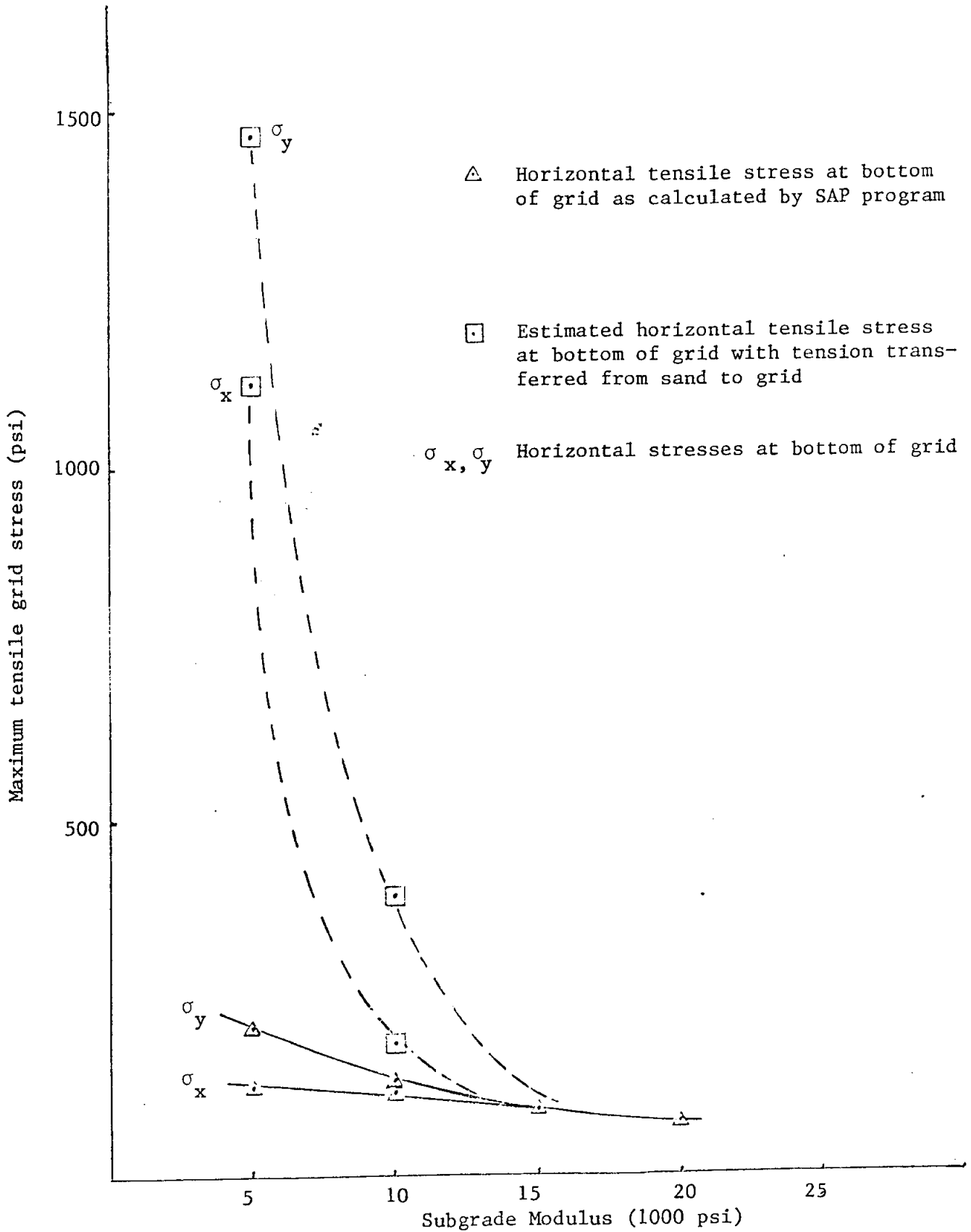


Figure 4. Stresses from SAP finite element analysis.

ELASTIC LAYER ANALYSIS USING CHEVN

The pavement simulation described for the finite element analysis was used in the elastic layer approach except that the grid was considered as two horizontal HDPE layers as shown in Figure 5. Again, no attempt was made to simulate the asphalt surface penetration layer.

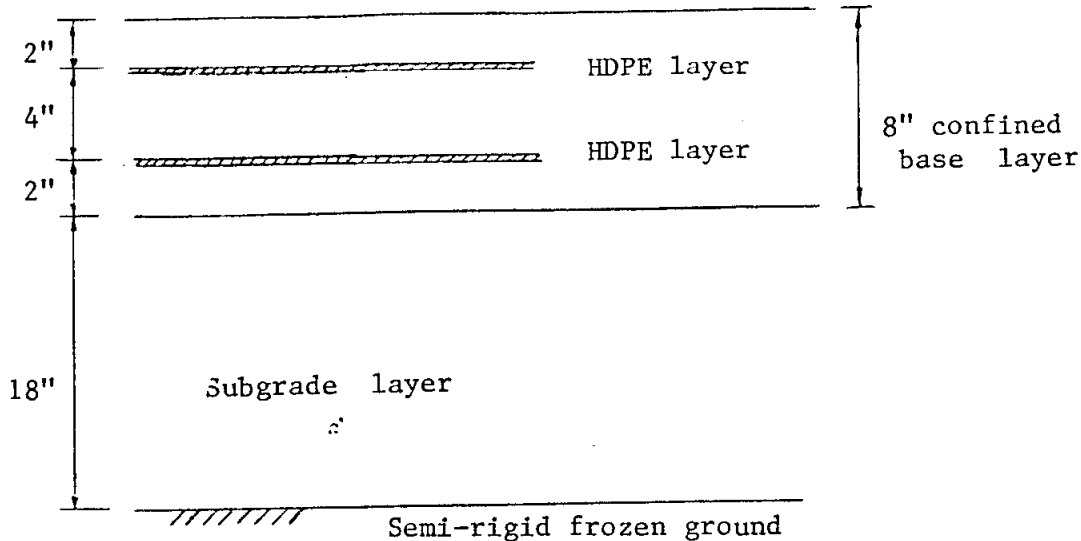


Figure 5. Idealized pavement structure for CHEVN analysis

Thickness of the plastic layers was based on the fact that there is 21.78 in. of HDPE in a 1 ft x 1 ft x 8 in. segment of confined layer, giving an equivalent horizontal layer thickness of 0.076 in. Material characteristics were as for the finite element analysis except that a modulus of 400,000 psi was used for the frozen ground, based on ice modulus values suggested by Johnson (12). Results of the analyses are plotted on Figures 6 and 7 using the same format as for the finite element analysis. Due to the different simulation techniques, there is a difference in the estimated stresses between the CHEVN and SAP results. However, the values are of the same order of magnitude which is encouraging when one considers the various approximations used.

The remarks made for the SAP analysis are pertinent to the CHEVN results viz:

i) In the unconfined layer system a failure condition exists when the horizontal stress at the bottom of the base layer becomes tensile while in the confined system this tensile stress can be transferred to the grid.

ii) The confined system theoretically requires failure of the grid material for pavement failure but the stress transfer technique results in strain incompatibility and care should be taken in interpreting these results. As a first approximation the transfer technique should be reasonable.

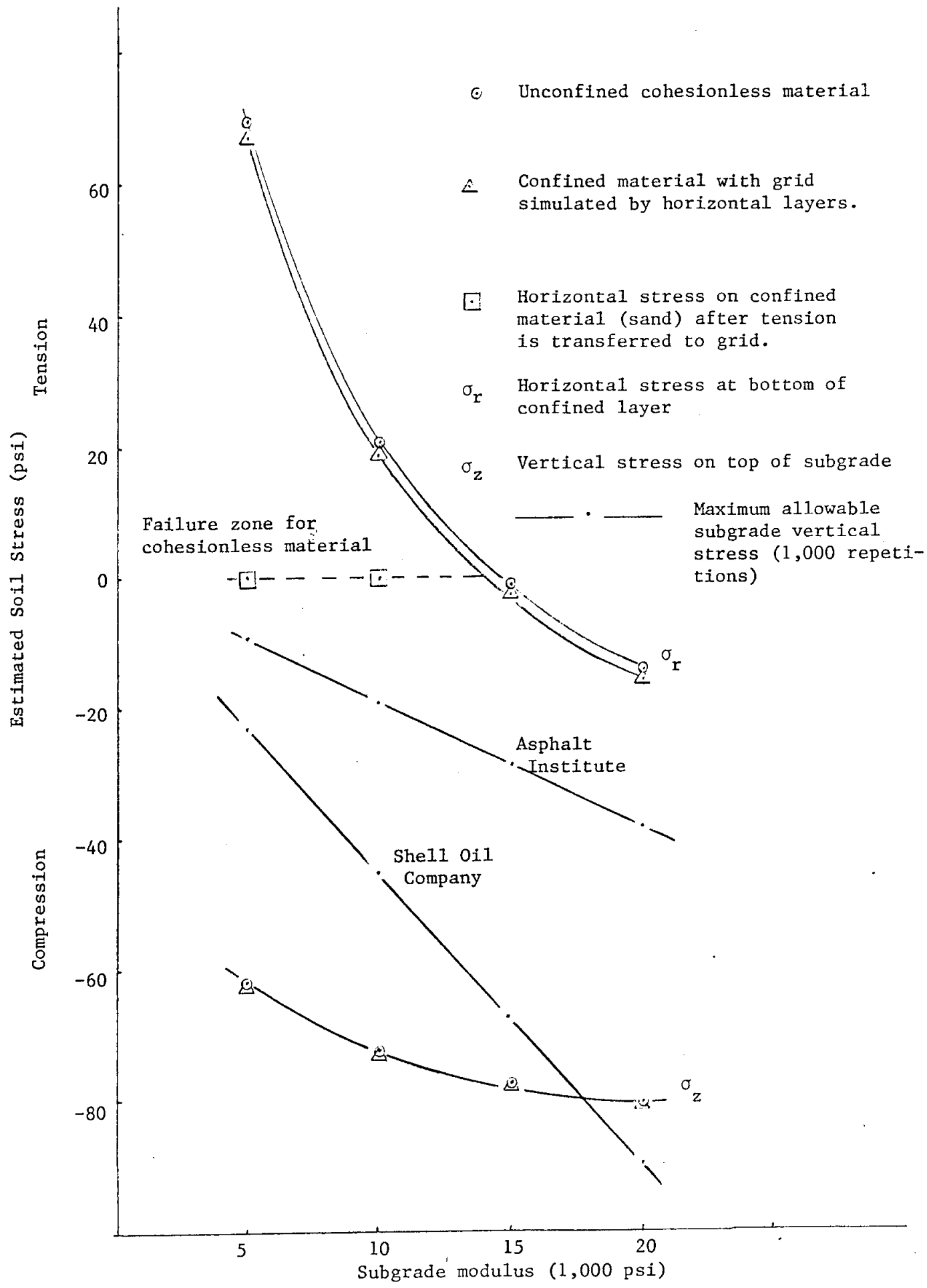


Figure 6. Stresses from CHEVN elastic layered analysis.

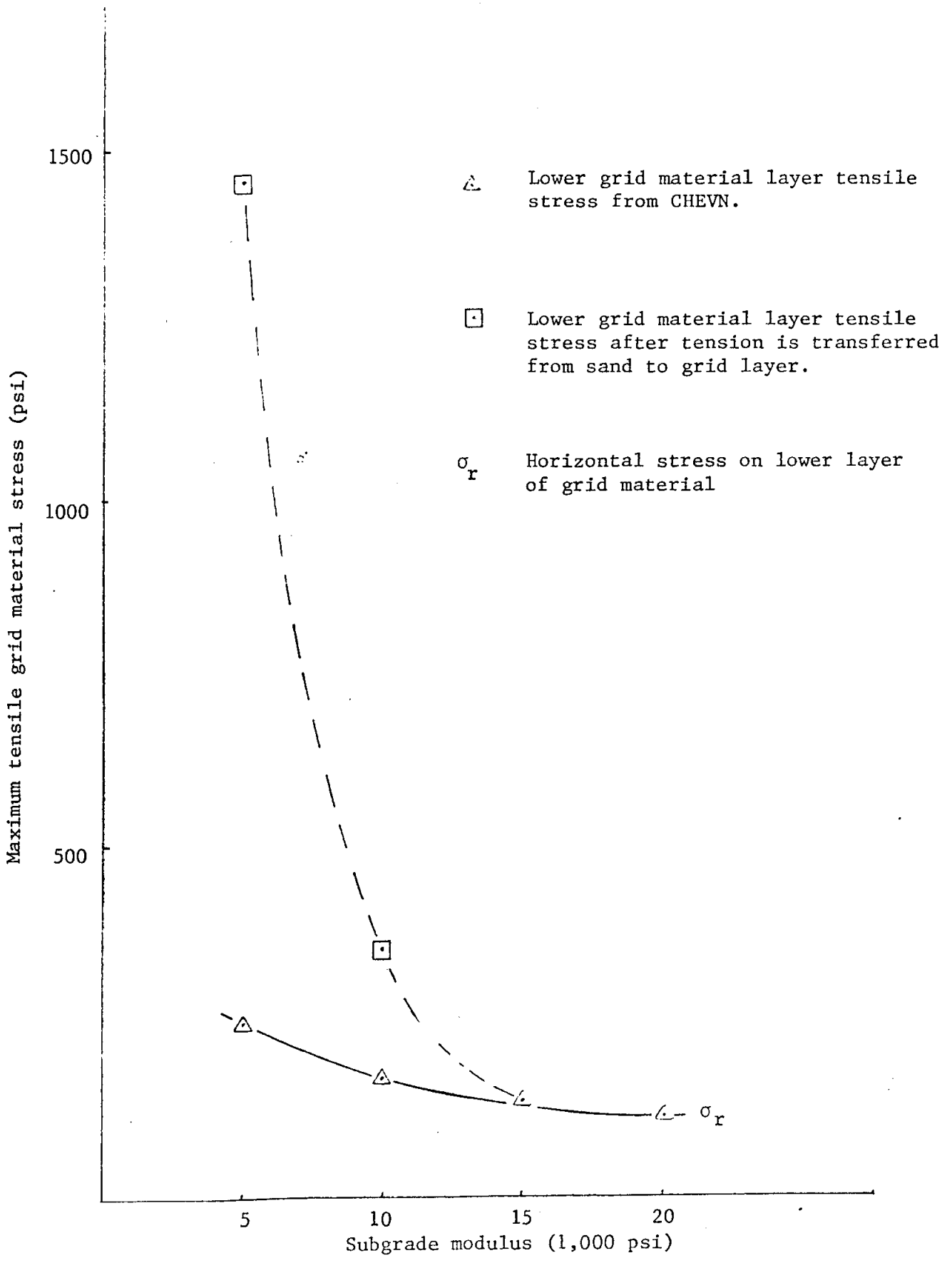


Figure 7. Stresses from CHEVN elastic layered analysis.

It should be noted that there is a striking similarity between Figure 4 (SAP) and Figure 7 (CHEVN) which may indicate that the arbitrary choice of simulating the grid by two horizontal layers in the CHEVN approach is reasonable. This should be investigated further since it may simply be coincidental to the specific system analyzed. Also, as for the SAP analysis, vertical subgrade stresses are excessive (See Figure 6) according to commonly used criteria.

VISIT TO WES

During January 1983, the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi was visited by the author and Mr. Billy Connor of the Alaska DOT/PF Research Section. Mr. Steve Webster, Principal Investigator for the very comprehensive full-scale grid installation tests being carried out at WES, discussed his research during the visit and exhibited some of the installations using the Presto HDPE grid. Results of the HDPE grid tests have not been published but Reference 1 gives an indication of the approach used in evaluating the grids. Impressions gained during the visit include the following:

- a) Grid confinement of cohesionless material effectively stabilizes the material in surface layer applications under the wheel loading described in Reference 1.
- b) Surface rutting occurs to some extent in all installations. This is consistent with the analysis approach based on the fact that the major effect of the confinement system is to provide cohesionless material with the ability to withstand tension.
- c) Construction of the confined layers is relatively simple and rapid using labor intensive methods and minimal mechanized equipment.
- d) Sealing of the grid surface is important in installations where the confined layer forms the pavement wearing course. Sealing by penetration (about one inch) of the sand with asphalt emulsion is effective.
- e) Grids of about eight (8) inch depth are necessary from a construction viewpoint. Shallower grids tend to be accidentally pulled out of the sand layer during blading operations of material on top of the grid layer.
- f) HDPE deteriorates under exposure to ultra-violet light and care should be taken in storing the material prior to installation.
- g) Black HDPE (containing carbon black) is less susceptible to the deterioration mentioned above and is thus preferable to white.

ANALYSIS OF POSSIBLE PAVEMENT ALTERNATIVES

The following analysis, using the CHEVN program, illustrates a possible method of evaluating alternative pavement structure performance under wheel loads. It should be stressed that this is an example. If an actual design is to be evaluated, site specific information is essential to ensure a reasonable simulation. Three alternatives are evaluated:

Alternative 1 (Figure 8):

Confined layer materials moduli:

HDPE E = 100,000 psi
 Sand E = 20,000 psi

Alternative 2 (Figure 9):

Base: Gravel E = 30,000 psi

Alternative 3 (Figure 9):

Base: Sand E = 20,000 psi

All materials assumed to have Poisson's ratio = 0.35

Wheel load : 36,800 lb circular.

NOTE: The assumed sand asphalt modulus of 200,000 psi is arbitrary and probably low.

Critical values calculated using CHEVN are:

POSITION	BOTTOM OF ASPHALT		BOTTOM OF BASE		TOP OF SUBGRADE Vertical Strain	LOWER HDPE LAYER STRESS	
	Horizontal Stress (PSI)	Horizontal Strain	Horizontal From CHEVN (PSI)	Stress After Transfer (PSI)		From CHEVN (PSI)	After transfer (PSI)
Alternative							
1	+194.7	+766.4 x 10 ⁻⁶	+15.7	-0-	- 4076 x 10 ⁻⁶	+ 138.7	+472.9
2	+165.0	+635.3 x 10 ⁻⁶	+26.7	+26.7	- 3111 x 10 ⁻⁶		No HDPE
3	+207.4	+768.4 x 10 ⁻⁶	+12.0	+12.0	- 3239 x 10 ⁻⁶		No HDPE

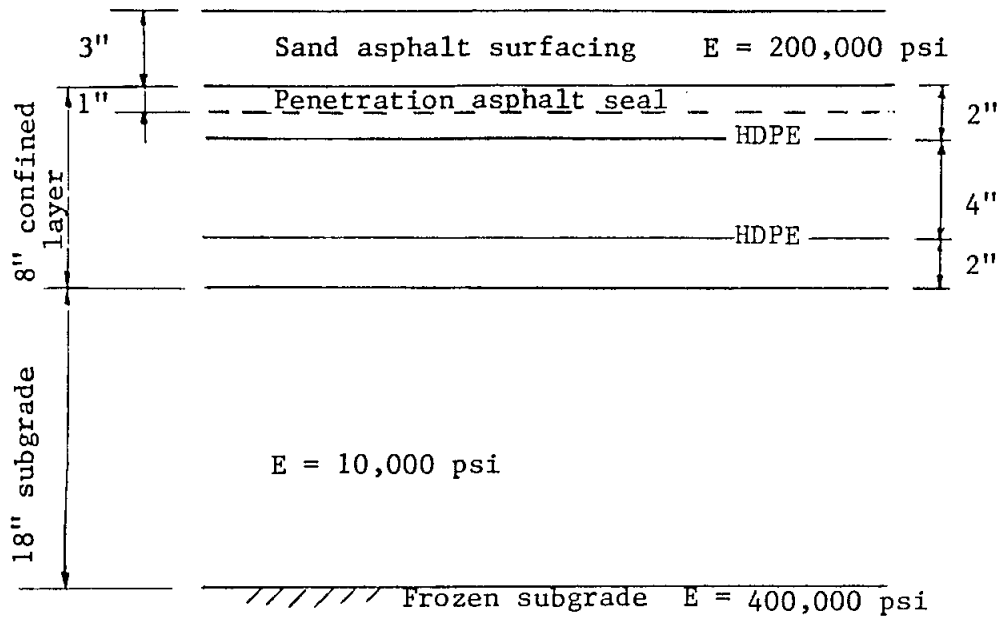


Figure 8: Alternative 1.

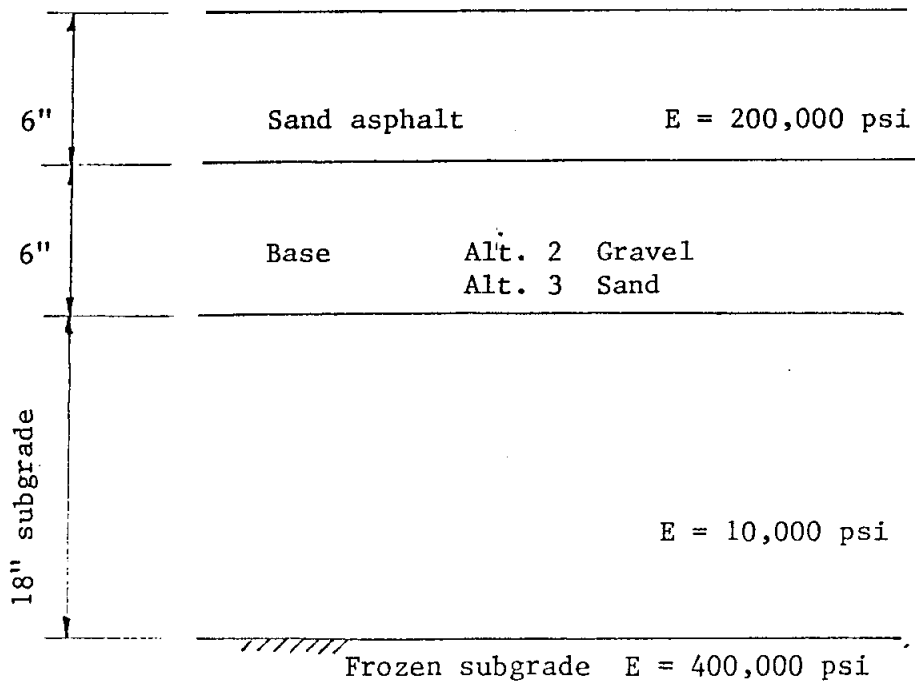


Figure 9: Alternatives 2 and 3.

Based on fatigue data for asphalt emulsion mixes published in Reference 9, the asphalt tensile strains as calculated should be acceptable for a low number (approximately 1,000) of repetitions of the wheel load. The subgrade vertical strains are marginal (acceptable according to Shell but not according to the Asphalt Institute) for the same number of repetitions, so rutting will probably be the expected mode of load-associated distress. Tensile stresses at the bottom of the base layer are unacceptable for all three alternatives as calculated, but in alternative one, these stresses are assumed to transfer to the confining grid material reducing base course tensile stress to zero, which is acceptable. The transferred stress results in a total tensile stress of 472.9 psi in the HDPE which is acceptable in terms of HDPE strength but may involve unacceptable strain levels. Overall, alternative 1, based on this simplified and idealized analysis, is preferable to alternatives 2 and 3 if the stress transfer approach is applied and if stress is actually transferred under service conditions.

CONCLUSIONS AND RECOMMENDATIONS

1. Bearing capacity analysis indicates that the confining grid system substantially increases the ultimate capacity of cohesionless material if one considers the effect of the grid to be that of introducing an apparent cohesion. This covers the situation where failure involves the lateral and upward displacement of the loaded material.
2. Finite element and elastic layer analyses can be used to model the system under certain assumptions. A detailed three-dimensional finite element analysis is probably the most likely method to provide a reasonable simulation of the grid confined system. Level of detail employed for the finite element analysis in this report was inadequate and results provide a first, crude approximation, at best, to actual system response.
3. Elastic layered system approaches require conversion of the grid to equivalent horizontal layers. The effect of this assumption should be checked.
4. Neither the finite element nor the elastic layer solutions model the behavior of cohesionless material effectively since it is assumed that the elastic modulus in tension is the same as in compression. Analyses involving grid confinement material were modified by assuming that all tensile stress in a confined layer is transferred to the grid, resulting in zero tensile stress on the cohesionless material. The approach leads to strain incompatibility in the confined layer and should be further investigated to ensure that the resulting stress and strain distribution is reasonable.
5. Analyses of a system with and without the grid confinement show little difference in stress distributions between the confined and unconfined system due to the low volume percent of confining material involved and the assumption of linear elastic behavior. However, if tensile stresses are transferred from cohesionless materials to the grid, the confined system exhibits a significantly improved response to load, due to its ability to carry tension in the confined layer.
6. Comparison of three arbitrarily chosen pavement systems using CHEVN indicate that, if the stress transfer technique is applied, a pavement with 3" of sand asphalt over an 8" sand grid layer (the top of which is sealed to a depth of 1" by penetration of asphalt emulsion) is better able to support the applied wheel load of 36,800 lbs. than either 6" of sand asphalt over 6" of compacted sand (modulus 20,000 psi) or 6" of sand asphalt over 6" of gravel (modulus 30,000 psi), for the assumed subgrade conditions.

This is an example of the use of the technique and should not be used for making any design decisions. Site specific material information is necessary to make a reasonable comparison of various design alternatives.

7. No thermal considerations were included in this evaluation. The behavior of the grid confining system at low temperatures needs to be investigated.
8. Laboratory tests on the engineering properties of the HDPE should be conducted at various temperatures to provide suitable design information, particularly since the joint weld strengths are likely to govern performance. This evaluation is based on the assumption that weld strengths of the grid are at least equal to the HDPE strengths.

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