**PORRAZ J. L., M.**, Panamerican Federation on Ocean and Coastal Engineering, Mexico

**SOLAR S., A.**, Control de Erosion, SA, Mexico

# THE USE OF GEOGRID (POLYETHYLENE MESH) IN THE REINFORCEMENT OF ASPHALT MIX AT THE INTERNATIONAL AIRPORT OF MEXICO

# L'EMPLOI DE GEORED (GRILLE DE POLYETHYLENE) POUR LE RENFORCEMENT DE LA MELANGE D'ASPHALT A L'AEROPORT INTERNATIONAL DE LA VILLE DE MEXIQUE

# DER EINSATZ VON GEOGRIDS (POLYÄTHYLEN-NETZEN) ALS ASPHALTVERSTÄRKUNG BEIM INTERNATIONALEN FLUGHAFEN VON MEXIKO CITY

Natural soil conditions within Mexico City, and its surroundings, comprise a constant problem for designers and maintenance engineers. One of the most characteristic cases is the constant re-paving of the asphalt surfaces at the International Airport. Cracking reflection made it necessary in order to prevent possible hazzards to aircrafts, but constant increase of asphalt base thickness also increased its weight and increased the causes of cracking reflection. Some zones within the airport had up to 2 m. of asphalt mix carpet. Reinforcement of surface layer by the inclusion of high density polyethilene geogrids (REDLON) not only decreased maintenance requirements with consequential economy of time and money, but also opened a new field of investigation on application of synthetic products for pavement optimization.

Der natürliche Boden in Mexiko Stadt und Umgebung,erzeugt häufige Probleme für Entwurfs und Erhaltungsingenieure. Eins der bezeichnenden Beispiele ist die dauernde Asphaltierung der Decken im Internationalenf Lughafen. Riss-Reflektion kam vor um Flugzeugumfälle zu verhindern.Aber die dauernde Vergrössung der Deckendicke und Gewicht der selben, vergrössert die Uhrsache der Riss-Reflektion. Einige Stellen im Flughafen hatten bis 2m. dicke Decken. Die Bewährung mit Geogrid (REDLON), von hoher Dichte, der Oberflächen, haben die Erhaltung vereinfacht und ergaben nicht nur eine Verschonung in Geld und Zeit, sondern öffneten ein neues Gebiet fur die Forschung der Benutzung von Kunststoffe für die Optimisierung von Asphaltdecken.

History has always been a strong factor in the number of elements that determine the behaviour of Mexico City and its citizens. Interesting it is to mention that even design of civil engineering projects must take into consideration the history of its ancient settlers: the aztecs. Tenochtitlan, Mexico City's name before the arrival of Spaniards, was an in-lake island, surrounded by minor cities to which the only conection was bridges, floating roads, and boat transportation. A great deal of Tenochtitlan's economy was based on tribute from other tribes, but also agriculture within the city limits comprised a good source of self-supply products. Urban and theocratic construction covered almost the whole surface of solid land; therefore, the waters of Texcoco Lake were the only solution for crop raising. Soil reclamation became a must for ancient formers in order to obtain as much space as possible.

Wood barges, incredibly similar to mangrove faciness used many years after by Neatherland people, were used as framework and containers of soil and straw mixture. This system, called CHINAMPAS, was the base of land recovery; which, by the time Spaniards conquered Tenochtitlan, had increased the original solid land surface.

Natural former sedimentation, stabilization works, deep water well perforation, drainage works, lake drainage, detritus accumulation, etc. have taken Mexico City's natural soil conditions to what nowdays Engineers cope with. A variety of clays, peats and lime over an acquiferous stratus.

Mexico City's Airport was constructed in 1932; since then complementary works have taken place and enlargement projects are being developed. 24 hours a day, 365 days a year, its landing tracks, side corredors, porking platforms and service areas are subject to severe transit. Failure parameters of asphalt pavement in airport surfaces are times superior and inflexible than common parameters for roads and highways. A 0.01 m. crack or differential settlement is enough to accident and aircraft running at 300 kilometers per hour. Periodical surveilance and inspection has to be made in order to prevent serious consequences.

BASIC CONCEPT

Asphalt mix surfaces subject to constant traffic are submited the fatigue forces. Tensile and compresive forces act on the granular material and the bituminous tack degrading it until failure. Water intrusion in between the gravel particles increases the degrading process accelerating the decomposition of the asphalt emulsion.

Our common descriptive diagram of an asphalt base- sub base system in the presence of an external load is as follows:

Fig. 1

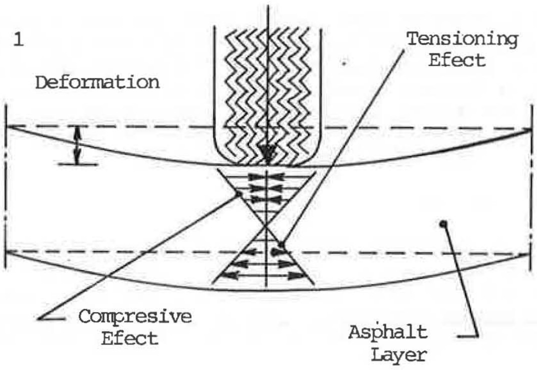
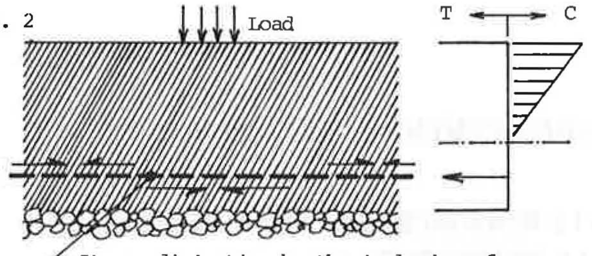


Fig. 2




Stress disipation by the inclusion of a reinforcing element. (GEOGRID)

Constant loading and unloading results in permanent deformation and cracking formation on the surface. For normal serviceability, maintenance work must be accomplished: Seal emulsions, re-paving, re-surfacing, etc. The heavier the traffic is, the more frequent service work must be proportioned.

On the other hand, maintenance projects must take into consideration that traffic must be suspended or detoured in order to fullfill specifications. Re-paving of a 2.5 kilometer long, 80 m. wide track needs approximately 30 days; a long period for a so over crowded airport.

Many antecedent cases on the use of auxiliar reinforcement for Asphalt Mix had been tried. Basically, all of them had failed for various reasons: lack of compatibility with the petroleum base of asphalt, lack of continuity with the over-all matrix, temperature failure of reinforcement material, etc. When consulted for an alternative solution, the authors had to consider all the problems encountered before in order to achieve maximum results.

The product selected was a 100% High Density Polyethilene Mesh manufactured by a special axial rotatory extrusion process: Redlon; mesh opening 27 x 27 mm. and 660 g/m2. The basic considerations for its selection were:

a) Former attempts of reinforcement inclusion in asphalt-gravel matrix had produced the creation of failure planes along the main line of reinforcement. If 19 mm. gravel was specified for the surface layer, the opening of the mesh had to be large enough to permit all gravels to pass through freely; not constituting a descriptive plane on the general structure. A 27 x 27 mm. apperture mesh was used.

b) Compatibility of materials was an important factor. A petroleum base polymer could easily incorporate into the asphalt without adherence mix. High density polyethilene was a suitable material for the specific project; although as we will mention ahead, certain problems with melting points were encountered.

c) High resistance was needed; among the various products analyzed Redlon mesh had the higher resistance for the grid apperture mentioned. During further investigation, it has been found that higher resistances are needed for optimus reinforcement. New evaluations, as they will be mentioned ahead, have produced new and more complete reinforcing elements.

PROPOSED DESIGN

All these considerations made, Airports and Auxiliary Services (ASA) in colaboration with Control de Erosion and Geosol, developed a new design for the over-carpeting of asphalt surfaces in lane 5D (RIGHT) -25I (LEFT). The design comprises the use of lower density materials in the systems sub-base and grid reinforcement in the asphalt mix layer.

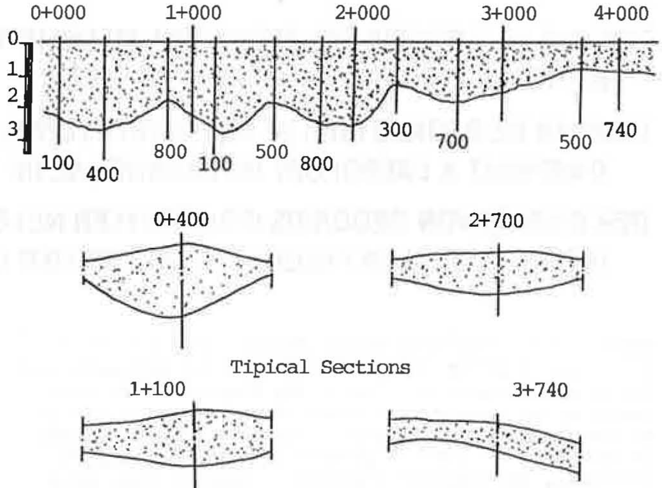
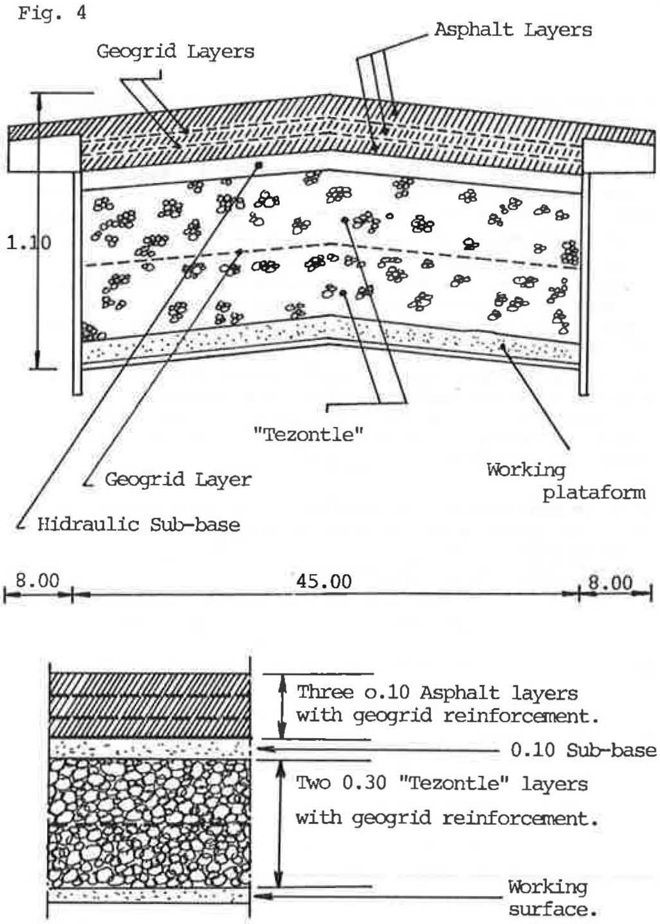



Fig. 3
Thickness variation in accordance to length of lane.

By decreasing the over-all weight of the structure the general sinking effect that had been observed during the life of the lane would be reduced. The general section of the compensated work is as follows:

Fig. 4



GENERAL INFORMATION OF CONSTRUCTION PROCEDURES

Aside from constituting an innovative design, this work was completed in a record time of 27 days. General cost of the job was of 335'013,000.00 Mexican Pesos, more or less 2'500,000.00 U.S. Cy.

Overall quantities of materials were:

| | |
|---|---|
| Excavation | 1,800 m3 |
| Asphalt emulsion FR-3 | 154.5m3 |
| Asphalt mix | 47,040,000 kg. |
| Geogrid | 42,000 m2 |
| Cutting | 3,600 m3 |

Operational program was followed accurately.

A 1.00 m. deep trench was dug at the center of the lane. For working purposes and with no structural function, a 0.10 layer of selected gravel and cement was compacted at the bottom of the trench. This made it easier for machinery and men to circulate and operate. Two 0.30 m. layers of a light weighted granular material known as - "TEZONTLE" were conformed; and an inter-layer of geogrid was used to confine and structurize the general 0.60 m. layer. TEZONTLE has a specific weight much lower than asphalt, generating a decrease in the weight of the nucleous of the lane.

A hydraulic sub-base was then constructed over the TEZONTLE layer. In order to impede the access of water to the nucleous and spoil the function, 0.10 cm. of sand and cement perfectly well compacted.

Finally, 3 layers 0.10 m. each of asphalt mix were laid; two of them still inside the trench and a final 0.10 m. over-carpet. In between each layer, a geogrid was placed.

During the construction procedures, various problems were encountered. The main one was the relatively low melting point of polyethilene. Due to the great velocity needed in finishing the work, an asphalt plant was placed right beside the airport. Trucks carrying the asphalt mix needed only to drive less than 4 km. in the worst case. The temperature specified for the geogrid not to melt or soften was settled in 115°C (264.6 °F); unfortunately, some trucks reached the advancing point with the mixture at 140°C. The heat captured within the two layers and the geogrid produced a certain balooning of the uper layer, which fortunately disappereared at night when the zone cooled off. In some areas, serious damage to the grid made it necessary to wait some minutes for the mix to lower its temperature. All the observations made during the 27 days that the job lasted were recorded for further analysis and investigation.

Once the job was concluded in April 1984, a one-year of monitoring and inspection was realized. Frequent surveys were executed in order to compone the general performance of the lane as to ancient re-carpeting procedures. Finally, in June 1985 the conclussions of the project were delivered.

LANE PERFORMANCE

General sinking and cracking reflection was reduced in almost 50% in problem areas as landing site and turn around heads. The 4.5 km. of the lane was monitored in order to compare the zones with and without geogrid. Common sinking of the lane is expected to be of 0.05 to 0.10 m. each year. Geogrid reinforced zones had only 0.02 to 0.04 m. sinking. Cracking reflection produced 0.01 - - cracks in the year lapse. Geogrid reinforced zones had no crackings above 0.005 m. in the worst cases. Such good effects as mentioned were redorded, and taking into consideration the problems encountered, made it necessary for a new investigation program directed by Control de Erosion.

DEVELOPMENT OF NEW MATERIALS

A thorough investigation on polymerus products was initiated. Among the most thermic resisting products, polyester was found to be the most suitable one. Although nylon has an even higher melting point, cost was also an interesting factor taken into consideration. Polyester fibers as manufactured for industrial purposes became an interesting way of achieving and overcomming the problems encountered.

Complete laboratory programs were started. The internal investigation of stress within an asphalt probe determined the most efforted zones in road surface. Tensile and compression stresses were measured and found to be of high importance. If a material to be used as reinforcement wants to be effective, high tensile resistance is needed. One thousand denier polyester fibers can stand up to 8 kg. before breaking.

Once a suitable fiber was selected, a manufacturing process had to be evaluated in order to produce a structure that could cope with the requisites stated prior in this work.

Non woven textiles are hard to handle and incorporate to an asphaltic mix. Although now a days successfull at-- tempts have been made in asphalt reinforcement with geotextiles, our design basis required of net structures that could not alter the general matrix. In other words, reinforced without really modifying the design parameters. Woven textiles became a more possible way of manufacturing reinforcement products.

Up to date, a great range of reinforcing textiles has been developed. Among them, we can find open mesh textiles with tensile capacities of up to 4,000 kg. per linear meter for asphalt reinforcement that can stand up to 170°C of heat impact. Laboratory testing has shown that life design of paved roads can be increased in 20 to 30%, and pavement thicknesses decreased in 0.03 to 0.05 m.

Mono-axial reinforcing textiles for soil structures with tensile capacities of up to 20,000 kg. per linear meter and Aparent Soil-Textile Friction Angles (ASTFA) of 95°.

Lateral designs have made it possible for marginal dike design with the use of such textiles and pre-casted concrete modular panels with wave energy dissipation system. Low cost piers of up to 4 m. deep could be constructed at a cost of 120 U.S. Cy. per linear meter.

Bi-axial woven textiles for sand and mortar containers for huge 1.5 m. diameter 15.0 to 30.0 m. long containers.

Still in investigation, other reinforcing elements for asphalt mixtures, concrete or soil cement, are the incorporation of various size polyester fibers at the moment of mixture. Ductility and secondary reinforcement is achieved and cracking formation reduced.

CONCLUSIONS AND RECOMMENDATIONS

The advancement on materials' technology has provided a wide new range of possibilities in design. The properties of some polymerus materials can cope directly with some of the needs in engineering projects. More information on the effects of inclussion of synthetic mate--

rials can only be achieved with the common will of progress and cooperation.

An open mind attitude is the key factor of technical advancement. Not only these applications, but hundreds more can be found in which by the optimum utilization of local resources and synthetic elements ancient problems can be turned into triumphant solutions.

REFERENCES

- Abdel Halim Omar Abdel Halim, Ralph Haas; Reinforced Flexible Pavements. Report for the Ontario Joint Transportation and Communication Research Program.
- Abdel Halim Omar Abdel Halim, Ralph Haas, William A. Phang, Kelly Mc.Gillivroy; Geogrid Reinforcement on Asphalt Pavements and Verification of Elastic Theory, University of Nottingham.
- T. Koyama, Design and Installation of Net Layer for Expressways: Tohoku main Road from Kawaguchi to Iwatsuki.
- T.S. Ingold; The Comparative Performance of Polymer Net Reinforcement.
- D. B. Sweetland; Polymer Grids in Ground Restraint Netlon.
- Mauricio Porraz; Geogrids and Geotextiles, its applications in Civil Engineering. Mexican Society of Soil Mechanics.
- Mauricio Porraz; The Use of Plastic Geogrids and Geotextiles in Soil Reinforcement, Erosion Control and Stabilization Works. 14th Meeting International Erósion Control Association.