ENGLISH VERSION...

Restauración de pavimentos: adherencia entre capas con interposición de geosintético de diferente abertura de malla

Restoration of pavements: adhesion between layers with geosynthetic interposition of different mesh opening

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Abstract

Generally, a deteriorated concrete pavement is restored by a layer of asphalt reinforcement. Currently, an appropriate intervention consists of interposing a geosynthetic material to delay the growth of existing fissures in the old pavement towards the new upper layer. The dilemma raised is the adhesion that is achieved between the layers of the old and new pavement by interposing a geosynthetic, because the effective operation of a pavement occurs when the layers that make it work together. Previous work experiences showed problems in the adhesion with the interposition of geosynthetics. Therefore, the study of the adhesion between a layer of Portland Cement Concrete and a layer of Conventional Asphalt Mixture is proposed, interposing a geogrid with different mesh opening, using as an adhesion agent an asphalt emulsion modified with polymer. It is found that the mesh opening geogrid that offers the best adhesion performance is that which has a mesh size of 40x40 mm. It is also observed that whatever the mesh size of the material, it generates a benefit compared to the system that does not consider the material, that is, to the intimate contact between concrete-asphalt by emulsion.

Keywords: *Restoration, geosynthetic, reflection crack, pavement, reinforcement*

Resumen

Generalmente un pavimento de hormigón deteriorado se restaura mediante una capa de refuerzo asfáltico. Actualmente, una intervención adecuada consiste en interponer un material geosintético para retardar el crecimiento de fisuras existentes en el viejo pavimento hacia la nueva capa superior. La disyuntiva planteada es la adherencia que se logra entre las capas del viejo y nuevo pavimento al interponer un geosintético, debido a que el funcionamiento efectivo de un pavimento se da cuando las capas que lo conforman trabajan solidariamente. Experiencias previas en obra arrojaron problemas en la adherencia con la interposición de geosintético. Por ello, se plantea el estudio de la adherencia entre una capa de Hormigón de Cemento Portland y una capa de Mezcla Asfáltica Convencional, interponiendo una geogrilla con diferente abertura de malla, utilizando como agente de adhesión una emulsión asfáltica modificada con polímero. Se encuentra que la abertura de geogrilla que ofrece mayor performance en la adherencia es aquel que tiene una abertura de malla de 40x40 mm También se observa que cualquiera sea la abertura de malla del material, este genera un beneficio en comparación con el sistema que no considera al material, o sea al contacto íntimo entre hormigón-asfalto mediante emulsión.

Palabras clave: Restauración, geosintético, reflejo de fisura, pavimento, refuerzo

1. Introduction

A pavement, which can be defined as a multi-layer system (structural package of the road formed by layers of different thicknesses and materials), must act together, therefore the intimate relationship between its components is of vital importance, allowing traffic and climatic stresses to be dissipated in the system (layers that make up the pavement) and not through the individual behavior of each layer (Tschegg et al., 1995).

The problem of lack of adhesion lies fundamentally in a significant decrease in the moment of inertia with respect to the pavement with good adhesion between its layers, which causes a decrease in rigidity, structural capacity and an increase in observable deflections (Campana and Rozada, 2004).

When the adhesion between layers is low, the pavement usually cracks early in response to transit stresses due to the internal energy consumption of the material (Maroni, 1993). This lack of bonding results in a bad or null distribution of strains in the total thickness of the pavement (Figure 1).

(Ponniah et al., 2006) explain that it is advisable to ensure a good bond between layers so that the entire pavement structure acts as a monolithic layer. (Leng et al., 2008) support this position and indicate that the bond between a Hot Mix Asphalt (HMA) layer on a concrete pavement is one of the important factors that can alter the useful life of the pavement (Leng et al., 2008).

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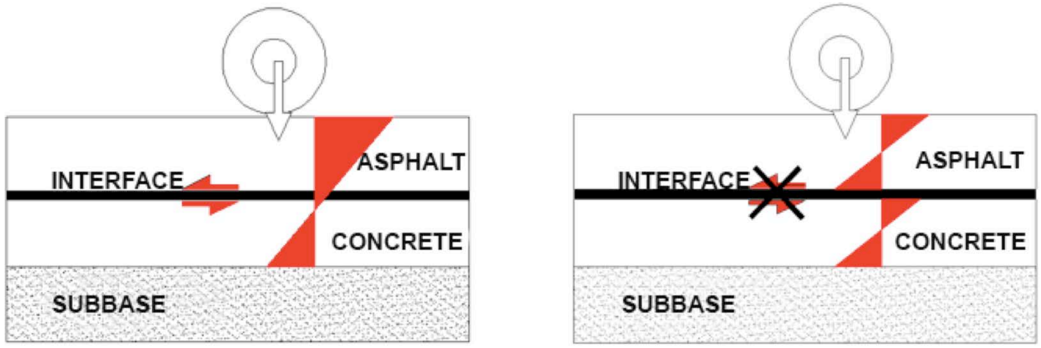

Figure 1. *Strength of the multilayer system: Left, adhered layers and right, not adhered layers*

The introduction of geosynthetic materials between the layers of the pavement is not done with the aim of improving the adhesion between layers but to absorb the strains generated by external loads. However, the phenomenon must be considered as it implies a discontinuity in the system interface.

The interface can be defined as a surface through which a discontinuity occurs in one or more parameters of the materials or the properties, such as density, modulus of elasticity, strength, coefficient of thermal expansion, fracture resistance, etc. (Álvarez, 2005).

In view of the above, this work proposes the study of the adhesion between a concrete layer and an asphalt layer, interposing a geogrid with a different mesh opening in order to analyze which is the mesh size that allows the greatest performance of the material in order to improve the adhesion between layers.

2. Experimental development

The measurement of attraction forces in a solid-solid interface is difficult to determine. Therefore, adhesion measurement techniques are developed through the determination of cut-resistant values to the joint. This method is appropriate from an engineering point of view because it provides information on the behavior of the system.

The system to be studied consists of a concrete slab (Hydraulic Portland Cement Concrete), an emulsion modified with polymer as adhesion agent (ECRR-M), an open-mesh geosynthetic material in polyester (MAC PET) and a conventional dense wearing course type CAC D19 used as reinforcement. We seek to quantify the adhesion that the geosynthetic with different mesh opening reaches between the layers in which it is placed, using as a reference or pattern the described system, without intermediate geosynthetic material between the layers.

2.1 Components

2.1.1 Concrete

The base concrete of the systems was dosed in the laboratory. It complies with the formula presented in (Table 1).

Table 1. *Concrete dosing*

Components	Weight (kg/m^3)	Density (g/cm^3)	Volume (cm^3)
Water	163	1.00	0.163
CPC 40 Cement	365	3.06	0.119
Coarse Aggregate 6:12	855	2.67	0.320
Fine Aggregate	1002	2.65	0.038
Air			0.015
Super-fluidifying agent	4.9	1.15	0.004
a/c	0.45		1.000
MRm (MPa) =	4.5	Medium flexural strength	
K =	0.75	$F'cm = (MRm / K)^2$	
F'cm (MPa) =	36	Medium compression strength	

2.1.2 Asphalt emulsion

The material used as priming (ECRR-M) is provided by an important company in the country. Characterization tests are conducted on this emulsion. The obtained parameters are shown in (Table 2).

2.1.3 Geosynthetic material

The material selected to study the adhesion in the system interface was obtained from an agreement signed with an important foreign company.

Table 2. *Characterization of the emulsion used*

Test	Unit	IRAM Standard	Result
Saybolt Furol viscosity at 25 °C	SSF	6721	33.7
Asphalt residue by distillation	g/100g	6719	65.3
Settling	g/100g	6716	1.7
Water content	g/100g	6419	37.5
Particulate Loading	-	6690	positive
Residue on sieve IRAM 850 mm	g/100g	6717	0.06
Tests on the distillation residue			
Residue penetration	0.1 mm	6576	70
Ductility	cm	6579	>100

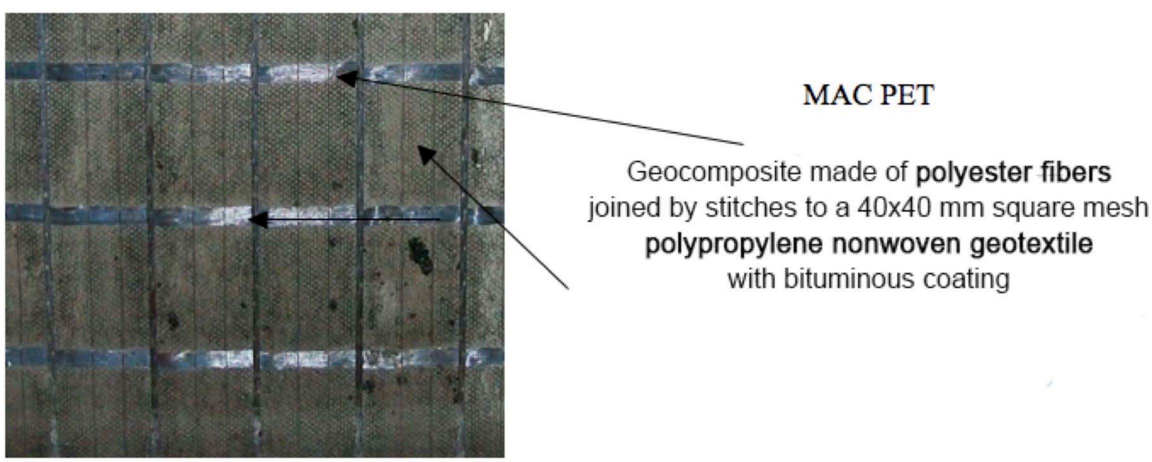

Figure 2. *Geosynthetic material*

2.1.4 Asphalt mixture

To determine the type of asphalt mixture to be used, factors such as the frequency of use in resurfacing and easily obtained materials that meet the technical specifications of a high-traffic pavement are taken into account.

Considering these factors, the asphalt mixture selected, as a reinforcement layer on the concrete, is a dense conventional hot mix asphalt concrete (CAC D19).

The mixture is characterized by the requirements set out in the General Technical Specifications Sheet of the National Roads Directorate (from the Spanish Dirección Nacional de Vialidad), section D VIII, Bases and hot mix asphalt wearing courses, 1998 issue (Dirección Nacional de Vialidad, 1998); by the specifications of 2006 of the Permanent Asphalt Commission (from the Spanish Comisión Permanente del Asfalto), and by the General Technical Specifications of Dense, Semi-dense and Coarse hot asphalt concretes, in point 3.1 Dosage criteria.

The results are shown in (Table 3). They are obtained through the Marshall test, which allows characterizing the mechanical behavior of an asphalt mixture. Prepared specimens are tested according to Standard VN - E9 - 86 (Norma VN-E9-86, 2008).

Table 3. *Results and Requirements for Concrete*

Conventional Asphalt CAC D19		
Test	***Result***	***Requirement***
Voids (%)	*3.5*	*3 - 5*
Bitumen - void ratio (%)	*77*	*68 - 78*
Stability	*919*	*>800*
Percentage of mineral aggregate voids	*15.0*	*>14*
Minimum binder percentage (%)	*4.9*	*5.0*
Stability - fluence ratio (kg/cm)	*3465*	*2500 - 4500*

Note: The asphalt concrete used is of the CA-30 type

3. Adhesion tests for different mesh openings

Adhesion tests are carried out with 150 mm diameter and 100 mm diameter specimens, such as Marshall specimens, to study the variability in adhesion in terms of the diameter of the specimen.

3.1 Preparation of specimens

Series of three 150 mm diameter specimens are made, which are molded by 50 mm thick concrete layers, on which 0.9 l/m^2 of ECRR-M emulsion is applied, the geogrid is placed and the CAC D19 asphalt mixture is compacted at 160 °C, using the Metabo compacting equipment (at speed 7) for 3 minutes (Figure 5).

The MAC PET geosynthetic material is selected for the experiments by taking variable mesh opening in order to analyze the adhesion reached by varying the contact surface between layers (Figure 3), (Figure 4), (Figure 5) and (Figure 6). As a comparison, the reference system is molded. This does not incorporate any geosynthetic material in the interface.

Figure 3. *Preparation of specimens*

Figure 4. *Placement of the specimen in the mold*

Figure 5. *Specimen molding*

Figure 6. *Molded specimens*

3.2 Testing procedure

To carry out the test, the jaws are designed to apply shear stress using the EMIC DL 10000 3.2 tensile testing machine (Figure 7), which is programmed at a test speed of 1.27 mm/min.

3.3 Results

The adhesion results considering different mesh openings of the MAC PET material are shown in (Table 4).

Figure 7. *Placement of the specimen in the experimental unit*

Table 4. *MAC PET adhesion with different mesh openings*

Material	Load on the interface (kg)	Deformation at maximum load (mm)	Strain at maximum load (MPa)	Work (kg.mm)
REFERENCE	73.73	2.72	0.06	141.73
MAC PET 20x20 mm	139.64	3.88	0.11	402.94
MAC PET 30x30 mm	143.12	6.64	0.11	626.43
MAC PET 40x40 mm	169.40	5.05	0.14	511.85
MAC PET 60x60 mm	118.23	2.41	0.09	229.73
MAC PET 120x70 mm	111.09	2.92	0.09	234.90

Note: the results are average of three determinations

(Figure 8), (Figure 9), (Figure 10), (Figure 11), (Figure 12) and (Figure 13) show the graphs obtained from the test of adherence per cut.

For (Figure 12) and (Figure 13) the calculations are made considering the two most representative curves.

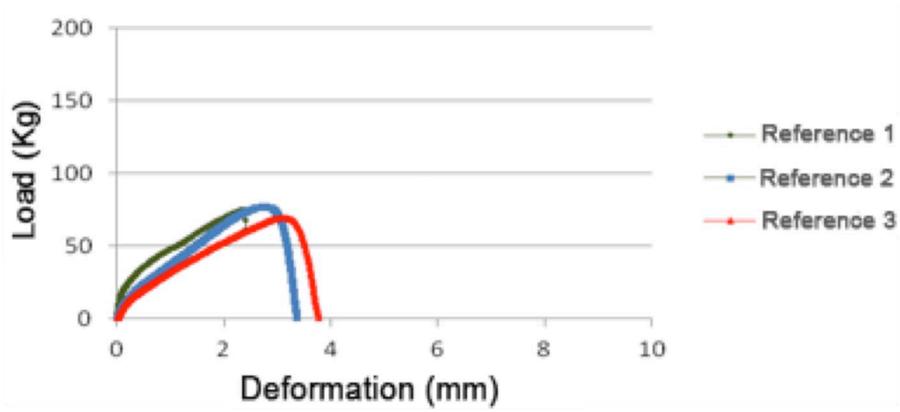

Figure 8. *Adhesion per cut, reference specimens*

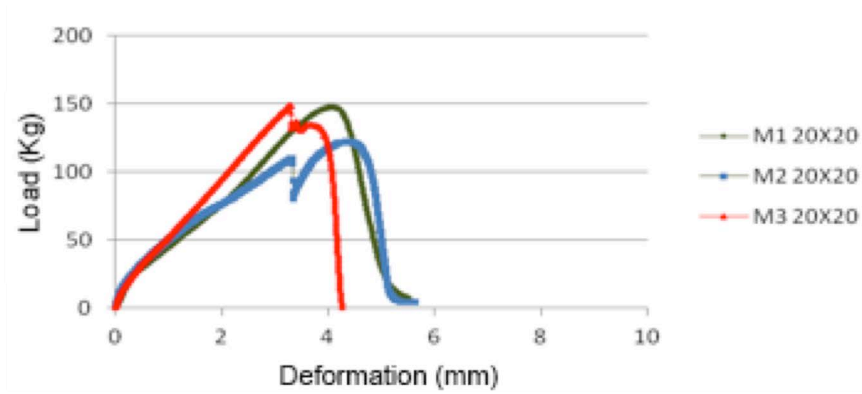

Figure 9. *Adhesion per cut, mesh opening 20x20 mm*

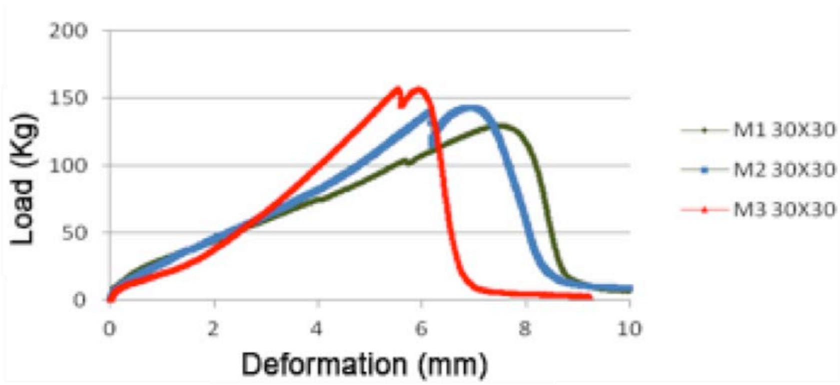

Figure 10. *Adhesion per cut, mesh opening 30x30 mm*

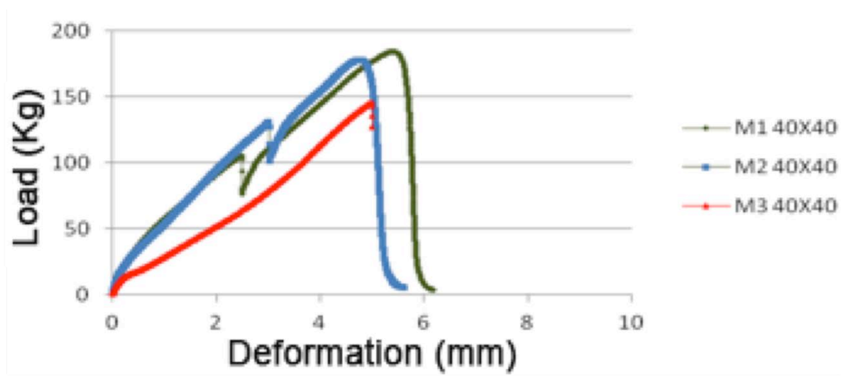

Figure 11. *Adhesion per cut, mesh opening 40x40 mm*

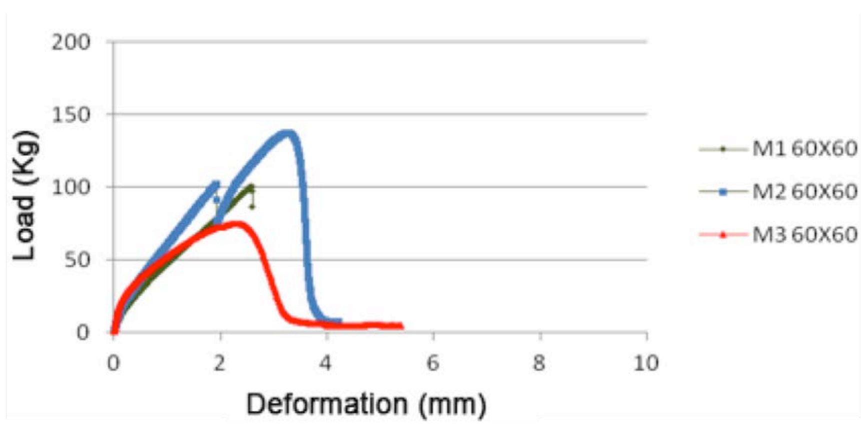

Figure 12. *Adhesion per cut, mesh opening 60x60 mm*

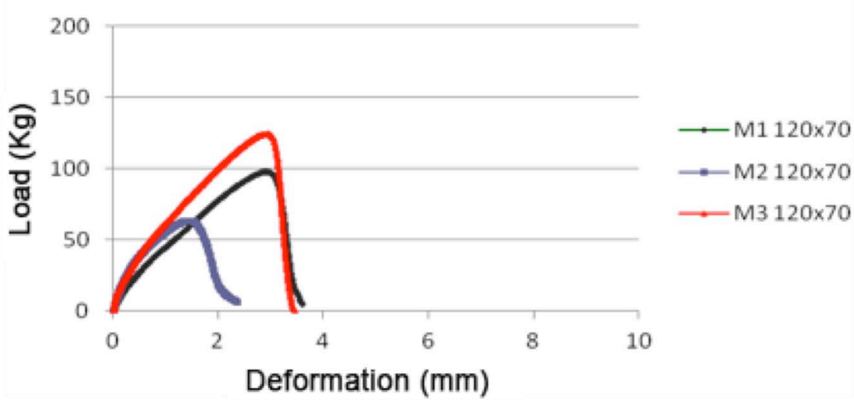

Figure 13. *Adhesion per cut, mesh opening 120x70 mm*

(Figure 14), (Figure 15), (Figure 16), (Figure 17) and (Figure 18) show the structure of the mesh in the test tube.

(Figure 19) show the test execution and (Figure 20) shows the adherence per cut results varying the mesh opening of the MAC PET material where it can be observed that the best performance of the material is obtained for an opening of 40x40 mm.

Figure 14. *Opening 20x20*

Figure 15. *Opening 30x30*

Figure 16. *Opening 40x40*

Figure 17. *Opening 60x60*

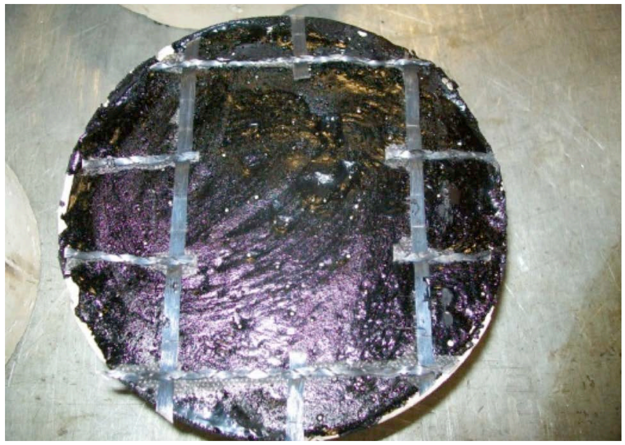

Figure 18. *Opening 110x70*

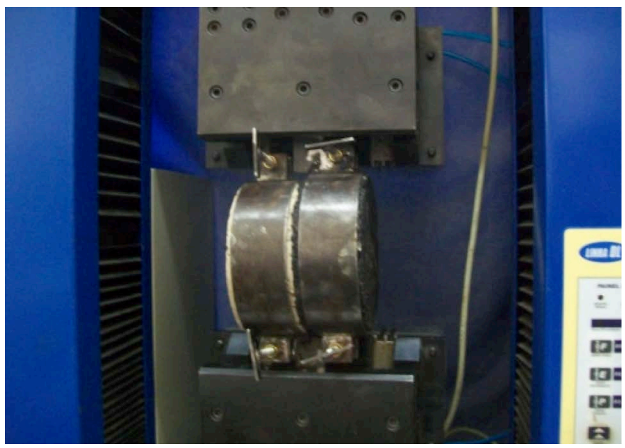

Figure 19. *Test execution*

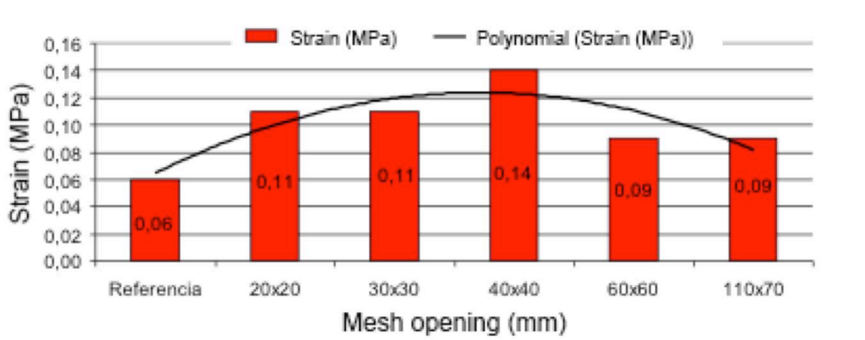

Figure 20. *Adhesion for different mesh openings considering the MAC PET materia*

It is believed that the larger the diameter of the specimens or core tested, the more representative are the determinations; this should be taken into account since the results of adhesion per cut made on specimens of smaller diameter (Figure 21), offered higher values, (Table 5).

Table 5. *Adhesion for MAC PET with different specimen diameter and mesh opening of 40x40 mm*

Diameter (mm)	***Load on the interface (kg)***	***Deformation at maximum load (mm)***	***Strain at maximum load (MPa)***	***Work (kg.mm)***
100 Reference	*190.51*	*0.55*	*0.22*	*156.3*
100 MAC PET	*370.42*	*0.96*	*0.44*	*465.3*
150 Reference	*73.73*	*2.72*	*0.06*	*141.7*
150 MAC PET	*169.40*	*5.05*	*0.14*	*511.8*

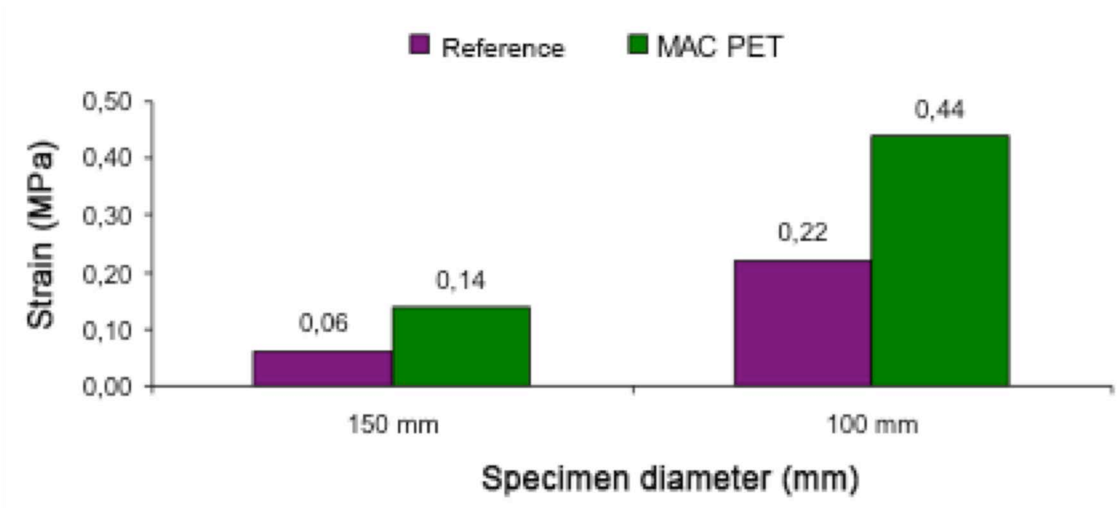

Figure 21. *Adhesion per cut for different specimen diameters*

The graph in (Figure 22) shows the variation in adherence between layers as the mesh opening of the MAC PET material increases.

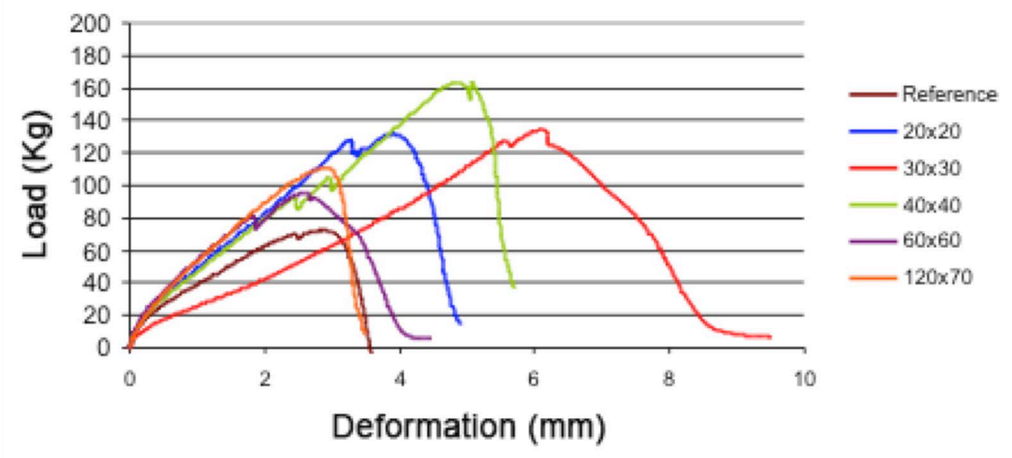

Figure 22. *Variation of adherence with mesh opening*

4. Conclusions

- *Interposing an open-mesh geosynthetic improves adherence in comparison to the reference system.*
- *The best adherence behavior is obtained for the mesh opening of 40x40 mm, for a maximum aggregate size of 20 mm.*
- *For 100 mm diameter specimens, the results were higher than for 150 mm diameter specimens.*

5. References

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