NEW WATERPROOFING SYSTEMS: THERMAL ENERGY REDUCTION DURING APPLICATION, IMPROVED SAFETY AND USE OF THERMO-SENSITIVE INSULATION BOARD.

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KEY WORDS
Composite waterproofing membrane; self adhesive membrane; thermal adhesive membrane; re-roofing

Abstract
In this document the experiences of new types of waterproofing membranes is discussed, manufactured with composite product technology. In these kind of products the waterproofing compound is stratified in different layers, each one having different composition and properties.

Specifically, the experiences related to the following products are presented:

a) Self – adhesive products

b) Products which become adhesive under slight thermal action;

c) Products for renovation and restoring.

The products belonging to the first group can be applied without any heating action, but only by pressure.

The products belonging to the second group develop the adhesion to the substrate only during the application of the second layer: therefore the adhesion of the bottom face takes place during the heating of the upper face.

The products of the third group perform a good adhesion even to slightly irregular surfaces, in order to be successfully used for renovation of old self protected slated membranes.

The following advantages are presented:

1) Reduced energy consumption during application, related to the fact that the adhesion is performed with a slight heat

transfer, if any;

2) Shorter waterproofing works, related to the easier application;
3) Lower risks for the roofers, due to a reduced use of heat sources.
4) Possibility to use complimentary products, e.g. thermo – sensitive insulation boards, otherwise difficult when combined with the traditional application techniques.

These advantages lead to environmental and economical benefits, appreciated both by the roofers and by the users of the civil work to be waterproofed.

In the document comparative laboratory tests are examined between the above mentioned products and the traditional ones, with respect to their technical features.

Finally, some practical on-site applications are illustrated, with respect to the actual performances on the waterproofed cover.

Sommario

Nel lavoro vengono presentate le esperienze relative a nuovi tipi di membrane impermeabilizzanti, ottenute con la tecnologia dei prodotti compositi, ovvero in cui la massa impermeabilizzante non è unica, ma è formata ed applicata in strati di diversa composizione.

In particolare vengono esaminate le esperienze relative ai seguenti prodotti:

a) Autoadesivi a freddo

b) Autotermoadesivi

c) Prodotti per rifacimenti

I prodotti del primo gruppo presentano la particolarità di poter essere applicati senza apporto di calore, ma per semplice pressione.

I prodotti del secondo gruppo presentano la particolarità di aderire al supporto solo durante l'applicazione del secondo

strato successivamente applicato sopra di essi: La adesione sulla faccia inferiore viene realizzata per riscaldamento della faccia superiore.

I prodotti del terzo gruppo presentano la particolarità di aderire a superfici limitatamente rugose, così da poter essere impiegati con successo per rifacimenti di coperture con membrane ardesiate o ceramizzate, senza necessità di asportarle.

Questo genere di membrane innovative presentano numerosi importanti vantaggi:

1) Risparmio energetico poichè la loro applicazione avviene con un ridotto apporto di calore, o addirittura in assenza di esso;
2) Minori tempi di esecuzione della impermeabilizzazione data la maggiore facilità di applicazione;
3) Minori rischi e pericoli per il Personale che applica i prodotti, data l'assenza, o comunque l'uso ridotto, di fonti di calore.
4) Possibilità di utilizzo di materiali di difficile impiego, quali ad esempio supporti isolanti termosensibili.

Tali vantaggi si traducono pertanto in benefici di natura economica ed ambientale apprezzabili sia da parte degli applicatori sia da parte degli utenti dell'opera civile.

Nel lavoro vengono inoltre esaminate le prove comparative di laboratorio fra i differenti tipi di prodotti e le loro prestazioni in comparazione con i prodotti tradizionali.

Vengono infine esaminate alcune applicazioni pratiche condotte con i nuovi prodotti, ed il loro risultato di esercizio sulle coperture impermeabilizzate.

Zuzammenfassung

Im Arbeitsbuch werden Erfahrungen vorgelegt betreffend neuer Dachbahnen, erzielt durch die Technologie kompositer Produkte, die nicht aus einer einzigen Abdichtungsmasse bestehen aber aus Schichten dessen Zusammensetzung unterschiedlich ist.

Es werden hauptsachlich Erfahrungen untersucht betreffend folgender Produkte:

a) Selbstkaltklebende Produkte

b) Thermisch aktivierte selbstklebende Produkte

c) Produkte fur die Renovierung

Produkte der 1sten Gruppe werden ohne Warmezusatz aufgebracht, nur durch einfachen Druck.

Produkte der 2ten Gruppe haften nur dann am Untergrund an, wenn die 2te Lage auf Diese aufgebracht wird: die untere Schicht haftet sobald die Obere erwarmt wird.

Produkte der 3tten Gruppe (beschieferte Bahnen) haften an rauhen Untergrunden an und werden deswegen bei Renovierungsarbeiten eingesetzt.

O.G. innovativen Bahnen weisen vielfaltigen Vorteilen auf:

1) Energieersparnis, da die Verlegung solcher Produkte ohne grossen;

   Warmeaufwand (bzw. keinerlei) erfolgt;

2) Die Verlegezeit sinkt wesentlich.

3) Reduziertes Risiko fur die Verleger/Dachdecker, dank der Absenz bzw. reduziertes Verbrauch von Warmequellen.

4) Anwendungsmoglichkeit besonderer Materialien, wie z.B. warmeempfindliche Dammstoffe.

Daraus ergeben sich positive Vorteile im Bereich Umwelt bzw. Ersparnis, welche sowohl von den Verlegern/Dachdeckern als auch von den Abnehmern verwertet werden.

Im Arbeitsbuch werden die Prufergebnisse der unterschiedlichen Produkten untersucht und mit den Ergebnissen der Traditionellen verglichen.

Schliesslich werden praktische Anwendungen mit diesen neuen Produkten ausgefuhrt und untersucht und die Auswirkungen auf den abgedichten Bedachungen gepruft.

Résumé

Pendant l'activité on va presenter les expériences avec les nouveaux types de membranes imperméabilisantes obtenues grâce à la technologie des produits composites où la masse imperméabilisante n'est pas "unique" mais est realisée et rangée en couches de différentes compositions.
En particulier, on va examiner les expériences des produits suivants:

a) auto-adhésifs à froid

b) auto-thermoadhésifs

c) produits pour les réfections

Les produits du premier group présentent la particularité de pouvoir être appliqués sans l'apport de la chaleur mais grâce à simple pression.

Les produits du deuxième group n'adhèrent au support que pendant l'application du deuxième couche successivement rangé sur eux.

L'adhésion sur la face inférieure se réalise avec l'échauffement de la face supérieure.

Les produits du troisième group adhèrent seulement à surfaçes rugueuses, si bien qu'ils peuvent être utilisés avec succés pours les réfections de couvertures avec membranes d'ardoise ou de céramique sans la nécessité de les enlever.

Ces types de membranes d'innovation apportent beaucoup d'avantages importants:

1) Epargne énergétique du moment qu'elles sont rangées avec un apport réduit ou, tout simplement, sans l'utilisation de la chaleur;

2) Temps reduits de réalisation de l'imperméabilisation grâce à la facilité d'application;

3) Risques et dangers reduits pour le personnel en considérant l'absence - ou l'utilisation reduite - de la chaleur;

Possibilité d'utiliser des materiaux difficiles, par exemple des supports isolants thermosensibles.

Ces avantages se traduisent en bénéfices économiques et du milieu appréciables soit de la part des applicateurs soit de la part des usagers des ouvrages civiles.

De plus, dans l'activité on va examiner les essais comparatifs de laboratoire et leurs prestations en comparaison avec les produits traditionnels.

Enfin on va examiner quelques applications pratiques effectuées en utilisant les nouveaux produits et les résultats sur les couvertures imperméabilisées.

WRITERS

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INTRODUCTION

The aim of this presentation is to show some recent experiences in design, manufacturing and application of a new generation of waterproofing polymer based bituminous membranes, structurally built with the composite product technique.

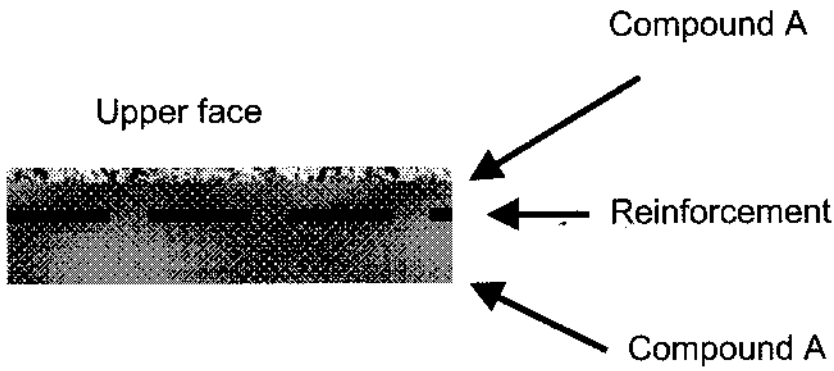

Figure 1 Section of "traditional" membrane

A recent development in the production of the polymer based bituminous membranes for waterproofing has been the introduction of the composite materials' technique. In these kind of products different materials are factory pre-assembled in order to obtain a stable and steady finished product. Actually, traditional waterproofing membranes are already a good example of a composite assembly, being the waterproofing mass (the so-called compound) and the reinforcement the most important materials.

In such a kind of membranes, the waterproofing mass is wholly of the same chemical nature, i.e., for example, APP or SBS modified bitumen.

In this presentation we will discuss the practical experiences on membranes whose waterproofing masses are different, through the membrane's thickness, therefore having a schematic structure as reported in the following Fig.2:

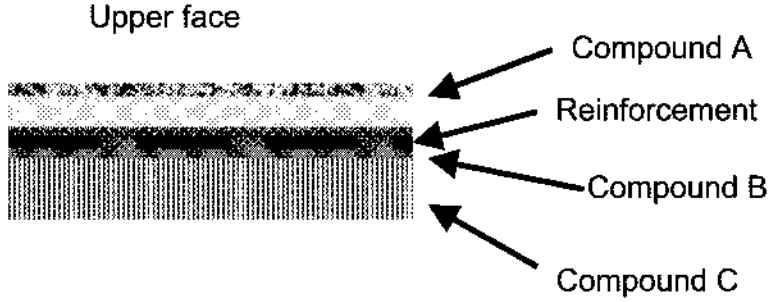

FIG 2 – Section of Composite membrane

The above indicated structure can be further improved, solving some manufacturing problems, in a way shown by the following Fig. 3

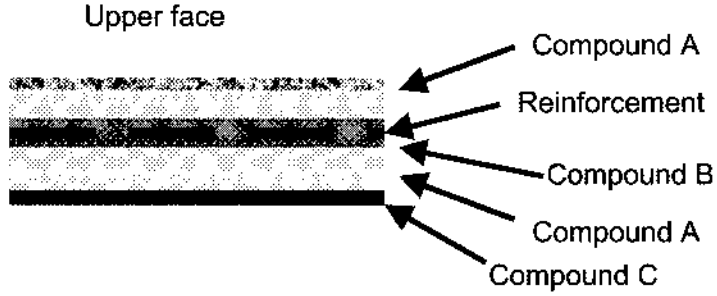

FIG 3 –Section of Composite membrane with a thin layer on lower face

Such a product structure, if properly designed and manufactured, allows to solve some specific problems, which the everyday practical experience teaches us as most relevant, such as for example:

- Improved adhesion of the membrane to the support, due to a specific formulation of the waterproofing mass of the bottom face ;
- Improved resistance to external exposure (e.g. UV radiation) due to a specific formulation of the waterproofing mass of the upper face:
- Improved saturation of the textile reinforcement, due to a specific formulation of the compound used for its impregnation; this enables to improve some mechanical features, which we know are strongly affected by the actual saturation of the reinforcement.

Obviously, as previously recalled, during design and manufacture of these products, some problems must be solved, such as:

- Adhesion between the chemically different compounds;
- Consistency of physical characteristics - e.g. thickness of the different layers of the waterproofing compounds which constitute the membrane.

Using a proper manufacturing technology and combining different compounds it is practically possible to produce a large series of innovative products. Our interest, as this presentation shows, has been focused mainly on the following three products:

- Self adhesive membranes
- Thermally-activated adhesive membranes
- Membranes specifically designed for re-roofing

Self adhesive membranes adhere to the substrate simply by pressure, without any contribution of thermal energy, i.e. heat.

Thermally activated adhesive membranes develop their adhesion to the substrate after application of the upper layer.

Therefore they are applied loose-laid, and due to their special formulation, it is sufficient the heat transmitted by the torch application of the upper layer, to perform their adhesion to the substrate. Their use, therefore, is in double-layer assemblies, where the waterproofing system is made out of at least two layers.

In the third group we included the membranes specifically designed for re-roofing operations, where generally surfaces are not smooth and properly prepared. It is quite often encountered the case of a re-roofing performed over old self protected membranes, with slate or ceramic granules: an improved adhesion over this specific substrate surface can be an effective success factor for the waterproofing job.

As it clearly appears, the study of such products introduces new and fascinating aspects, involving an endless series of tests and evaluations; moreover it must be noticed that the performance evaluation of these products must take into account the fact that their introduction in the market has been quite recent, at least with the feature of the composite materials' technique.
Nevertheless, the practical results so far obtained in their evaluation seems to deserve, as per our judgement, a certain attention.

Hereunder we report some significant experiences in the study and evaluation of the above mentioned systems.

The purpose of this presentation is not to discuss the specific formulations and technology used for manufacturing; it is rather to present the possibilities which can be achieved by using the composite – compound technique.

Another general consideration is that we assume that some of the fundamental features of the waterproofing membranes (like for example the mechanical resistances, the bending properties, the waterproofing resistance, etc) have been previously verified.

We will therefore focus our attention to the specific performances of these new systems.

Unless otherwise specified, the tests were conducted following the EN 12317-1 Determination of shear resistance of joints and

the directives générales UEAtc pour l'agrément des revetement d'étanchéité de toitures *"essai de pelage"*.

1. SELF ADHESIVE MEMBRANES

We took into account the following variables:

Pressure: Self adhesive membranes adhere to the substrate simply by pressure. Two different pressure conditions have been taken into account, in order to evaluate the different behaviours as influenced by the different application conditions. The two pressure conditions during application investigated are 1 Kg/sq cm and 0.5 Kg/ sq cm. The first one equals, with some approximation, the pressure exerted by a man with a pressure roller (diameter 80 mm, length 200 mm, active surface 10 sq cm), with a weight of 10 Kg. This condition simulates the so-called "hand rolling" over the surface.

The second pressure value, 0.5 Kg/sq cm, equals to the pressure exerted by a foot of an operator, whose weight is 80 Kg.

Temperature: according to pressure-sensitive adhesion principles, the adhesion can be strongly affected by temperature; we took therefore into account three different application temperatures: 10°C, 23°C, and 40°C.

Substrate: In roofing structures many different materials are currently used. Our study has been confined to the study of four different substrates: Expanded polystyrene, Concrete, Steel, and Precasted concrete. This last substrate has been simulated with a fiber-cement panel, whose smoothness is similar to that of precast concrete.

All surfaces, with the exception of EPS and steel, have been primed with an oxidised bitumen solution.

Ageing: In the evaluation of the waterproofing membranes performance ageing takes an important role, in order to evaluate the consistency of the technical features after application. In our study, we took into account different ageing conditions at 80°C, for 7, 28 and 180 days.

The summary of the factors taken into account is therefore the following:

Pressure	1 Kg/sq cm; 0.5 Kg/sq cm
Application temperature	10°C; 23°C; 40°C
Substrate	EPS; Concrete; Steel; Precast concrete.
Ageing	7, 28, 180 days at 80°C

Subsequently, we faced the problem of selecting the tests which better investigated the product performances. These tests had to be simple, significant, and selective on the possible weak points of the waterproofing systems.

We selected the following tests:

Peeling test: with this test it is possible to evaluate the adhesion of the membrane to the substrate. This test was considered particularly important in the evaluation of a self adhesive membrane, whose adherence to the substrate is a critical factor. The method used is the *"essai de pelage"* directives générales UEAtc pour l'agrément des revetement d'étanchéité de toitures.

Resistance of joints: it was investigated the resistance to traction of joints, following the norm EN 12317-1 Determination of shear resistance of joints.

Also this test was considered particularly indicative for the evaluation of the technical performances of such kinds of product.

We conducted many tests, crossing variables in order to frame the practical performances of the product.

Hereunder we report the most interesting results which, as per our judgement, will give some contribution to the development of this new category of products.

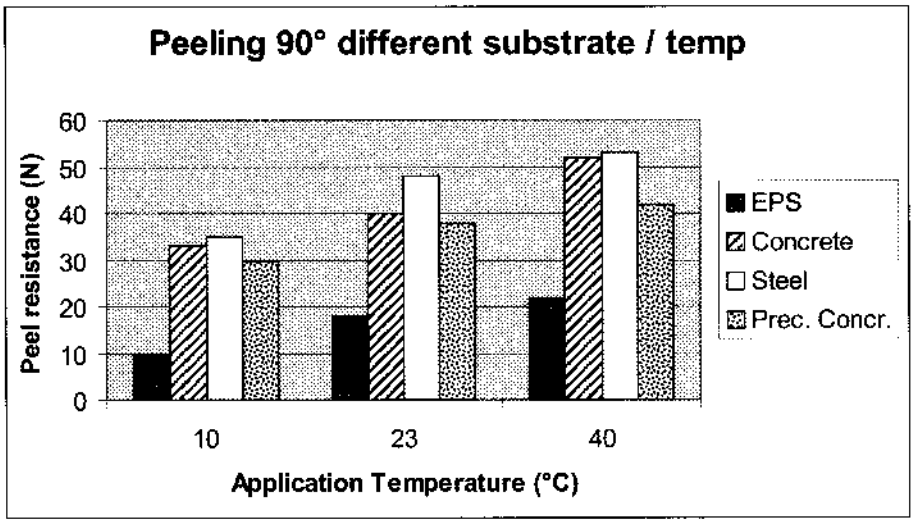

Fig. 4 Peeling strength of self adhesive product applied over different substrates at different temperatures. Test performed in standard conditions after application.

The adhesion to substrate is clearly influenced by the temperature of application, and depends on the type of surface. This adhesion test was performed after application: for this reason it is not very significant, at least for the evaluation of the practical performances on a roof.

Considering pressure application, this variable appeared less important than expected, at least in the range considered (0.5

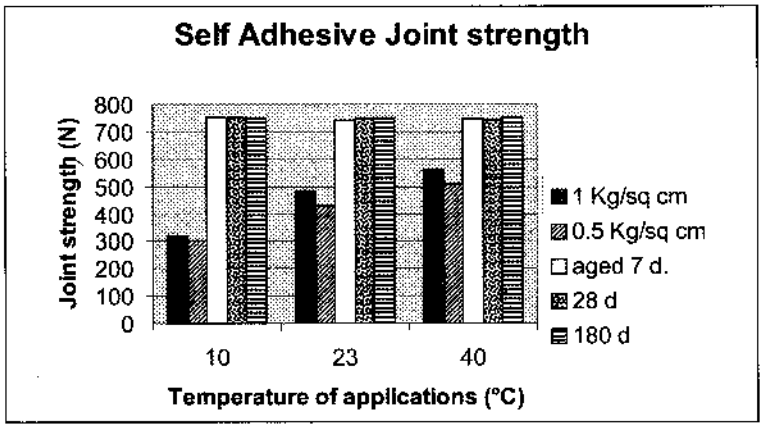

Fig. 5 Self adhesive joint strength at different pressures before and after ageing

Kg/sq cm and 1 Kg/sq cm). This apparently leads to consider that a pressure of 0.5 Kg/sq cm is sufficient to perform a good adhesion. In Fig. 5 is reported the joint strength of a self adhesive product applied at different temperatures and at the two pressure conditions considered.

As in previous experiences regarding peeling resistance, the adhesion values are influenced by temperature: at higher temperatures the adhesion is better. It has not been tested, however, a great difference between pressures of 0.5 Kg/sq cm and 1 Kg/sq cm.

What is in our judgement interesting is the high increase of joint strength after one single week of ageing at 80°C. The system was left alone in the ageing chamber without any pressure. In fact, it has been experienced the break of the sample outside the joint.

Ageing at 28 days and at 180 confirmed the same results, i.e. break of sample outside the joint.

The actual performance of the product over the roof is also influenced by the temperature, as it happens for traditional polymer bitumen membranes, belonging all these items to the thermoplastic products' family.

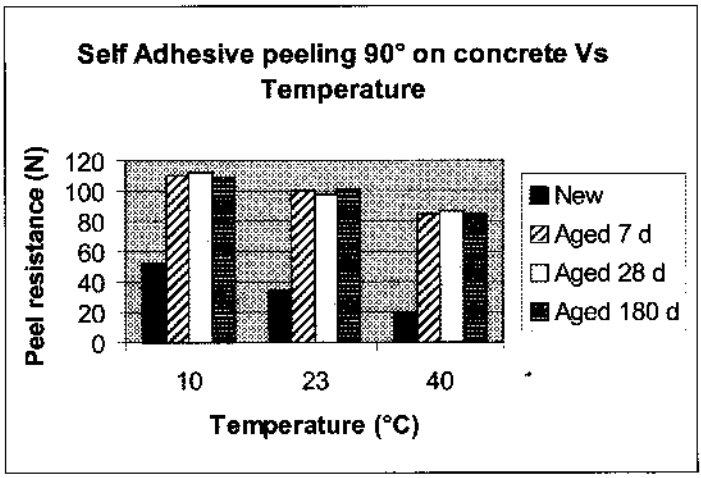

Fig. 6 Self Adhesive peeling strength on concrete Vs. temperature, new and aged

Fig. 6 and Fig. 7 in fact show peeling resistances of a self adhesive membrane over two different substrates (Concrete and Steel).

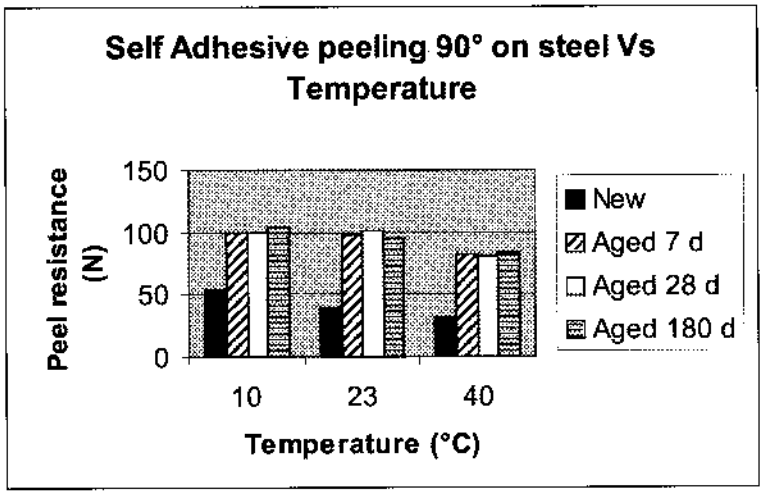

Fig. 7 Self Adhesive peeling strength on steel Vs temperature, new and aged.

For evaluating in an even more stressing condition, we performed the adhesion and the peeling tests at the same temperatures, i.e. 10°C, 23°C, 40°C. It can be noted that the peeling strength decreases with temperature, clearly indicating the thermoplastic nature of the product. But after a simple week of ageing at 80°C, and submitting the samples at the peeling test, at the same temperature, the values appear to have increased quite sharply. Longer ageing, 28 d and 180 d show the same results, without any practical change.

On other substrates, the results were similar. Specifically, on EPS it was experienced the delamination of the substrate, indicating that the adhesion force of the membrane to the substrate was higher than the cohesion resistance of the substrate itself.

After the tests performed on the self adhesive product we can submit the following conclusions:

- Self adhesive membranes perform an immediate adhesion to different substrates; the adhesion force, evaluated with the peeling test, depends on the type of surface and on the

temperature at which this adhesion takes place. Pressure application plays certainly an important role but at the pressures tested – supposed to be reached quite easily during an accurate but standard application – no practical differences were experienced.

- The adhesion of the membrane increases dramatically with ageing – i.e. exposure to heat for a certain period. The shortest ageing period – 7 days at 80°C – proved to be enough to have great increases in adhesion.
- The adhesion of the membrane decreases with an increase of temperature, following the thermoplastic behaviour of the traditional polymer – bitumen membranes. If the membrane performed ageing, however, the rate of decrease is lower than without any ageing. Its adhesion, both to substrates and to itself in the joints, is comparable to traditional polymer – bitumen membranes.

2. THERMALLY ACTIVATED ADHESIVE MEMBRANES

Thermally – activated adhesive membranes are designed mainly for two purposes:

- To be used on substrates sensible to heat (for example EPS). No direct heat in fact is necessary to perform the adhesion, since it takes place during the torch application of the following layer;
- To save energy during the application. A supplementary benefit is represented by the increased safety on the site operation, since the application of the first layer is done without any hazardous operation (torching).

To evaluate the performances, the peeling test was chosen, run out over the same substrates used for the self adhesive product, i.e. EPS, Steel, Concrete, and Precast concrete, simulated by a fiber-cement panel.

The waterproofing systems were therefore the following ones:

- Substrate (EPS, Steel, Concrete, and Precast concrete); Concrete and fiber – cement panel were previously primed with oxidised bitumen solution;

- Thermally activated membrane, loose laid with 10 cm overlaps both on the side and on the end lap;
- SBS based membrane, (ICITE conformity certified), 4 mm, torch applied. Immediately after application it was imposed to the system a pressure of 0.5 Kg/sq cm (as in the previous case, simulating the "foot walk pressure" of the operator).

Hereunder are reported the most interesting results concerning the evaluation of these systems.

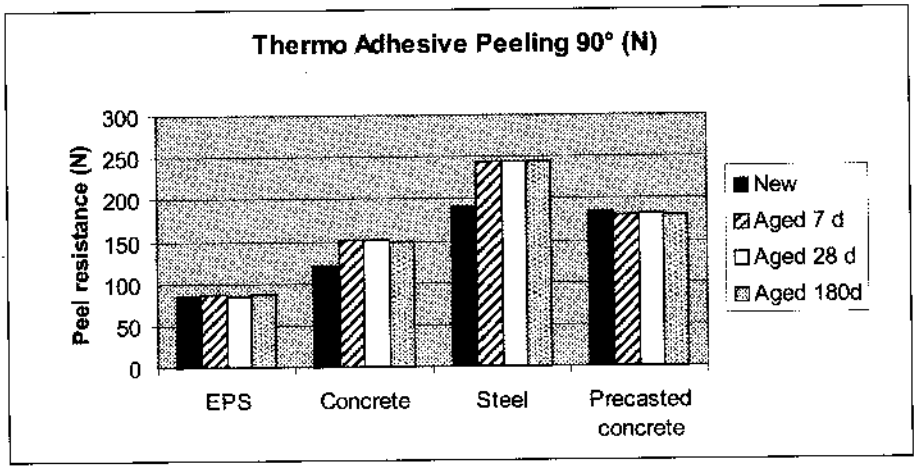

Fig. 8 Thermo adhesive systems. Peeling strength.

In Fig. 8 the values of the peeling strength performed by the four different systems are reported. As a comment to these results it can be said that:

- The peeling over EPS was satisfactory in the sense that the substrate delaminated itself, proving that the adhesion to the substrate was greater than the internal cohesion of the substrate itself. Also over concrete, during some trial sessions, was experienced the same event, most likely due to a poor surface resistance of the concrete. It can be assumed, also in consideration of the satisfactory values obtained, that the adhesion takes place at a reliable extent.
- The peeling over steel and precast concrete shows higher values, as experienced in traditional polymer bitumen membranes, probably as an effect of their smoother and more resistant surface.

- Ageing acts as an increasing factor for all systems. In EPS and concrete values did not show any increase due to the fact that the system had already reached its peak value. In case of EPS (and, at some extent, concrete) as explained beforehand the surface cohesion was lower than the adhesion of the system; in most cases regarding concrete the system lacked internal adhesion (e.g. detachment of 2nd layer of membrane by the first layer, delamination of one of the two layers, etc.). In any case, the values reached were judged satisfactory and no further investigation was performed.
- Increased ageing times, e.g. 180 days did not show any change in the basic properties. It can be said, as in the previous case regarding self adhesive membranes, that after ageing of 7 d at 80°C the system practically reaches its peak values.

3. MEMBRANES SPECIFICALLY DESIGNED FOR RE-ROOFING

An interesting development in the application of the composite – compound membrane design proved to be the product specifically designed for re-roofing operations.

Common experience teaches us that in re-roofing operations it is generally difficult to have properly prepared surfaces: often the "old" roof is covered with self protected products whose identity is lost, roofers do not like (and often is very difficult) to prepare properly the surfaces before renovation, and so on.

We tried to follow the idea of manufacturing a product with improved adhesion to surfaces with limited irregularities. This case, practically, turned out to be quite appreciated in case of renovations over membranes whose upper surface was alternatively slated or with ceramic granules.

The product studied is a traditional membrane having, on its bottom face, a thin (about 1 mm) layer of a polymeric bituminous compound with increased adhesion properties.

To evaluate its performances, the following systems were tested:

a) Re-roofing membrane applied over old slated membrane;
b) Traditional membrane, APP modified with ICITE conformity certificate, applied over old slated membrane;
c) Same as b), except that the old membrane was previously conditioned by an application of oxidised bitumen (Type 85/25) layer, hot applied, at a rate of 1 Kg/sq m;
d) Traditional membrane, SBS modified with ICITE conformity certificate, applied over old slated membrane;
e) Same as d), except that the old membrane was previously conditioned by an application of oxidised bitumen (Type 85/25) layer, hot applied, at a rate of 1 Kg/sq m.

An old roof is considered as an APP modified membrane naturally aged for 5 years on an existing roof.

All the systems were submitted to the peeling test, in order to evaluate adhesion to the old substrate. The results are summarised in following Fig. 9:

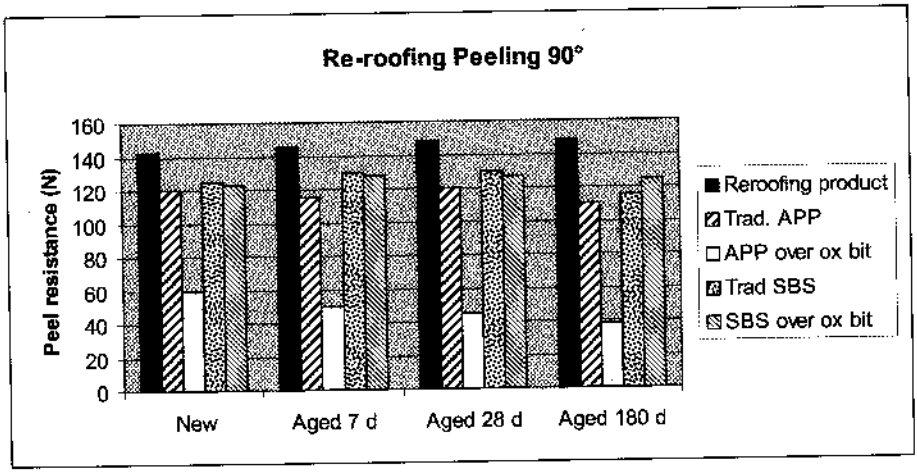

Fig. 9 Resistances to peeling of different re-roofing systems, new and aged.

As a general statement, it can be noted that:

- The product specifically designed for re-roofing performed a good adhesion; ageing did not have a detrimental effect on the performances, which remained practically around the same values, with a slight increase;

- Traditional APP membrane showed a decrease of the performances after ageing; its values are in any case comparable to SBS based membranes which, on the contrary, tend to increase their peeling resistance. In any case both membranes show a lower peeling value than re-roofing membranes;
- The practice of conditioning the old roof with oxidised bitumen is harmful in case of application of an APP based product – peeling values are low and tend to decrease with ageing. It gives, on the contrary, no direct benefit with SBS based membranes. In this case this practice can be accepted for surface conditioning.

CONCLUSIONS

This presentation, due to time reasons, was obviously not complete. We tried anyhow to show an overall panorama on some results which we obtained with the formulation, design, manufacturing and application of the composite – compound membranes, which as per our feeling appear to be a promising development in the bitumen modified membrane market.

We understand that the studies concerning this category of membranes are just at the beginning, and an enormous amount of studies, tests, and evaluations must still be done.

But it is certain that, in the future, the demand for more reliable products, easier to apply, and able to solve specific problems will be constantly higher. It must be taken into account that also safety regulations and energy saving policies will play a role which will become more and more important.

We hope, with this study, that we were able to give at least a small contribution in this direction.

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