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Long-Term Performance of Geomembranes by Oxidative Induction Time

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요 지

폐기물 매립지 바닥층 및 사면에 적용되는 평편 형 및 텍스쳐어드 형 고밀도 폴리에틸렌 지오멤브레인의 장기성능이 검토되었다. 특수 설계된 스크래치 장치를 이용하여 인위적으로 지오멤브레인 표면에 결함을 부여하였다. 결함 및 미결함 지오멤브레인의 역학적 및 마찰특성, 화학저항성 및 자외선 저항성 그리고 산화유도시간 등이 검토되었다. 텍스쳐어드 형 지오멤브레인의 마찰특성이 평편 형 지오멤브레인 보다 우수함을 알 수 있었다. 끝으로 화학저항성, 자외선 저항성 그리고 산화유도시간 측정결과로부터 결함이 없는 지오멤브레인과 텍스쳐어드 형 지오멤브레인의 장기성능이 결함이 있는 지오멤브레인보다 우수함을 알 수 있었다.

Keywords : Long-term performance, Smooth and textured type HDPE geomembranes, Artificial surface defects, Chemical and ultra violet light resistances, Oxidative induction time(OIT)

Abstract

Long-term performance of smooth and textured type HDPE geomembranes which were used to the liner and slope systems of waste landfills was examined. Artificial surface defects were added to the surface of geomembranes by scratch addition apparatus specially designed. The mechanical and frictional properties, chemical and ultra violet light resistances and oxidative induction time(OIT) of geomembranes were examined for the cases of defective/non-defective surfaces. Frictional properties of textured type geomembranes showed more excellent than those of smooth type geomembranes. Finally, it was known that the long-term performance of non-defective and textured geomembranes was better than that of defective geomembranes through chemical and UV resistance and OIT tests etc.

1.Introduction

Geomembranes are very low permeable synthetic membrane liners or barriers to be used in waste landfills. In general, the high-density polyethylene (HDPE) is widely used as raw material to manufacture

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geomembranes(Koerner 1998). There are 2 types of geomembranes surfaces, smooth and textured types, which are applied to the waste landfills. Among them, the textured type geomembranes show better frictional behaviors than the smooth type geomembranes for the applications as liner and slope systems of waste landfills.

If the surfaces of geomembranes are damaged by soils, sands, and construction equipments etc. during waste landfill construction, the long-term performances of geomembranes would be decreased and this affects the stability of the waste landfill system (Giroud et al. 1989). Therefore, the long-term performance of geomembranes is dependent on the their surface conditions.

If the damage was occurred in the surface of the geomembranes, the weatherability to the UV, and chemical resistance to acidic, alkaline and leachate solutions should be decreased and this is the serious cause of the decrease of the long-term performance of geomembranes.

Especially, the oxidative induction times (OIT) of the defective geomembranes in leachate solutions are decreased rapidly than those of the non-defective geomembranes(Hsuan et al. 1993).

In this study, 5 type HDPE geomembranes having defective/non-defective surfaces were used to compare the long-term performance in the waste landfills through mechanical, frictional, chemical and UV resistance, OIT tests.

2. Experimental

2.1 Preparation of Samples

5 types of smooth and textured type HDPE geomembranes as FML (flexible membrane liner) were used and the specifications of these geomembranes were represented in Table 1.

1 smooth geomembrane and 4 textured geomembranes were used. In here, textured geomembranes were manufactured to improve the frictional properties between geomembrane and soil.

2.2 Addition to Defects in Geomembrane Surfaces

As shown in Fig. 1, defect addition apparatus specially designed was used to make the defective surface of geomembrane and this apparatus was attached to the typical mechanical test equipment.

The defective surface condition was considered as the inner state of waste landfills in Korea. Sandpaper (cw400) similar to the particle size of waste landfill soil was used to make the defective surfaces of geomembranes under confined load, 23kgf, defect

Table 1. Specification of geomembranes

Geomembrane	Type		Density (g/cm^3)
A	Smooth	Flat	0.950
B	Textured	Spray on	0.948
C		Hot embossed	0.948
D		Extrusion coated	0.948
E		Blown extruded	0.947

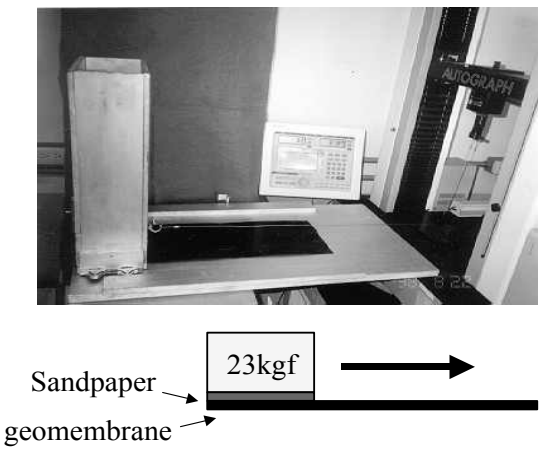


Fig. 1. Apparatus to make defective surface of geomembrane

addition speed, 100㎜/min, defect addition time, 10.

2.3 Experimental

2.3.1 Tensile and Puncture Tests

ASTM D 638 Type IV and FTMS 101C Test Method were adopted to test tensile properties and puncture strength of geomembranes.

2.3.2 Frictional Property Test

Friction angles between soils and geomembranes were tested by direct shear test method of ASTM D 5321.

2.3.3 Chemical Resistance Test

Chemical resistance of geomembranes in the leachate condition of the waste landfills was done in accordance with EPA 9090 Test Method.

Test temperature and duration of chemical resistance test were 95℃ and 360 days, respectively. Degree of chemical resistance were estimated by the tensile strength retention at every 60 days.

2.3.4 UV Resistance Test

Weatherability of geomembranes to ultraviolet light was done in accordance with ASTM D 4355 and the degree of UV resistance were estimated by the tensile strength retention. before/after UV treatment.

2.3.5 Oxidative Induction Times (OIT) Test

Oven ageing method was applied to geomembranes to maintain the same conditions as the inner state of waste landfills by ASTM D 5271. Ageing temperature and duration were 95℃ and 270 days, respectively. OIT was done in accordance with ASTM D 3895(standard method) and 5885(high pressure method), respectively.

3. Results and Discussion

3.1 Tensile Properties and Puncture Strength

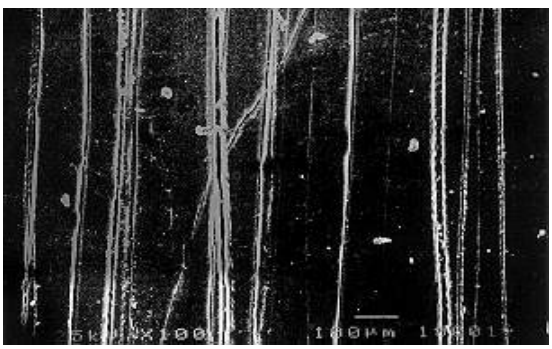
The defective surfaces of smooth and textured geomembranes were represented in Fig. 2.

From this, it is seen that the surface state of textured type geomembrane is better than that of smooth type geomembrane.

Tensile properties and puncture strength values of smooth and textured geomembranes were shown in Table 2. Tensile properties and puncture strength of both geomembranes were deteriorated with surface defects.

For textured geomembrane, these properties of

(a) Smooth type - A



(b) Textured type - D

Fig. 2. SEM photographs (×100) of defective geomembrane surfaces

Table 2. Tensile properties and puncture strength of geomembranes

Geomembrane	Tensile Property	
	Strength (kN)	Strain (%)
A/DA	45.4/36.7	750/643
B/DB	20.8/18.5	154/138
C/DC	21.4/19.7	150/142
D/DD	22.3/20.4	150/144
E/DE	23.8/22.1	153/1480

Geomembrane	Puncture Strength(kN)
A/DA	5.2/3.63
B/DB	1.77/1.37
C/DC	2.06/1.77
D/DD	2.35/1.77
E/DE	2.55/2.16

D means defective, e.g., DA is defective geomembrane A

blown extruded geomembrane were better than those of other textured geomembranes. It is thought that this is due to the manufacturing mechanism of blown extrusion method.

3.2 Friction Properties

Friction angles between soils and geomembranes were shown in Table 3.

Textured type geomembranes showed the larger friction angles than smooth type geomembrane with relative density of soil and this is due to the surface states of the textured type geomembranes.

Table 3. Friction angles between soils and geomembranes

Geomembrane	Relative Density (%)	Friction Angle (deg.)
A/DA	40 80	19.6/19.2 29.2/28.8
B/DB	40 80	29.5/28.3 32.3/31.7
C/DC	40 80	31.5/31.1 34.6/33.8
D/DD	40 80	33.3/32.5 36.2/35.7
E/DE	40 80	33.1/32.9 35.8/35.6

3.3 Chemical Resistance

Tensile strength retention of geomembranes for 360 days, 95(C leachate solution was represented in Fig. 3.

Smooth and textured type geomembranes showed no significant trends but it is seen that the chemical resistance of textured type geomembranes were better than that of smooth type geomembrane.

3.4 UV Resistance

Tensile strength retention of geomembranes to UV light was represented in Table 4.

As shown in the case of chemical resistance

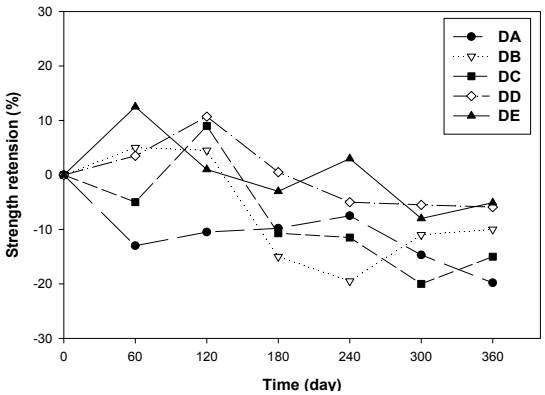


Fig. 3. Strength retention (%) of defected geomembranes at 95°C leachate solution

Table 4. Strength retention of geomembranes to UV treatment

Geomembrane	Strength Retention (%)
A/DA	85.4/78.3
B/DB	85.2/80.2
C/DC	85.5/81.6
D/DD	85.8/81.7
E/DE	86.8/82.3

results, UV resistance of textured geomembranes with/without surface defects were better than that of smooth geomembrane.

3.5 Oxidative induction times (OIT)

OIT values of standard(Std.) and high pressure (HP) method at 95℃ ageing condition for non-defective/defective geomembranes were represented in Fig. 4 and 5, respectively.

For standard and high pressure methods, OIT retained values of the textured geoemebranes showed better than those of smooth geomembrane.

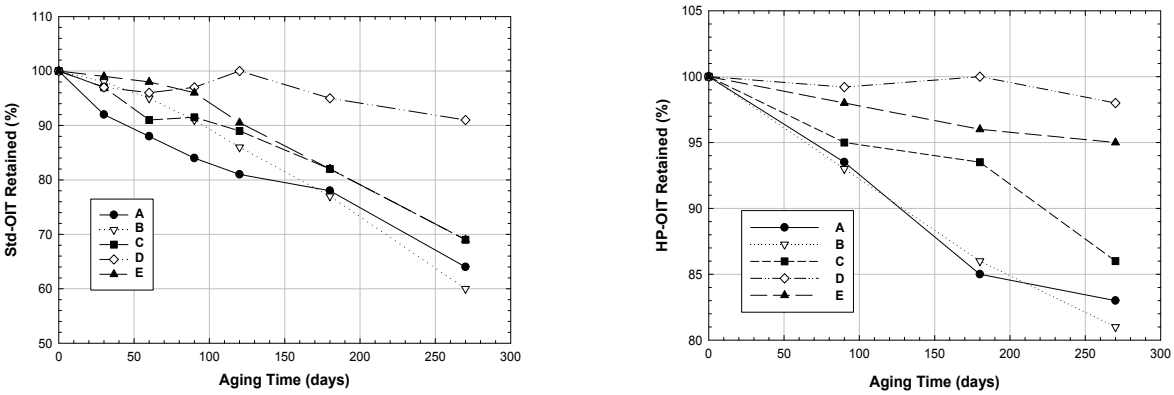
Oxidation reaction should be rapider if the oxygen were supplied to the damaged parts of defective geomembranes in the high pressure. The reason why OIT values of the textured geomembranes showed no special trends is due to the type of antioxidants, which were added to geomembranes.

For defective geomembranes, it was seen that the longer ageing times would accelerate the HDPE chain scission and this is the cause of the rapid oxidation reaction.

4. Conclusion

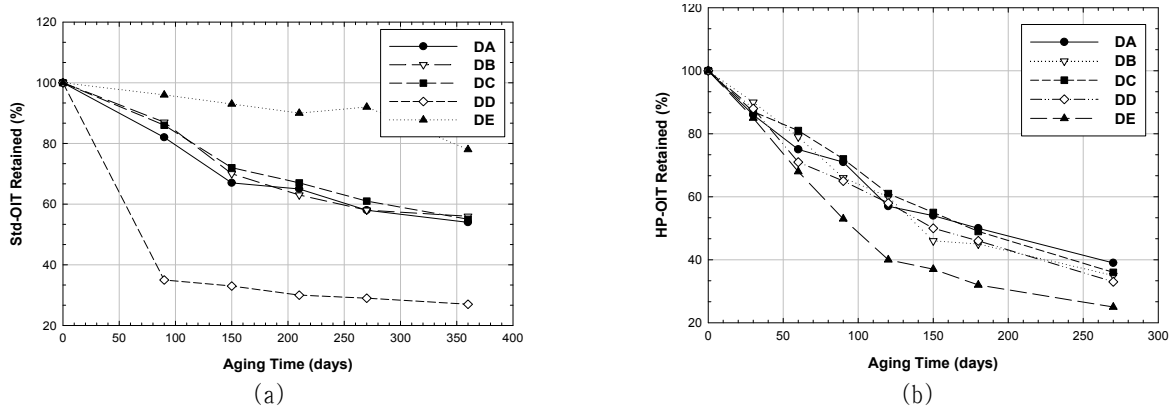
Smooth and textured geomembranes having the defective surfaces showed the deterioration of tensile properties and puncture strength.

For frictional property, textured geomembranes



(a) (b)

Fig. 4. Change in percent retained of Std-/HP-OIT values of non-defective geomembranes at 95℃ ageing condition



(a) (b)

Fig. 5. Change in percent retained of Std-/HP-OIT values of defective geomembranes at 95℃ ageing condition

have bigger friction angles than smooth type geomembrane with/without surface defects.

Especially, the defective geomembranes showed the significant decrease of chemical resistance and high pressure OIT values.

It is seen that the changes of mechanical and durable properties should influence the texturing process, type and composition of additive for textured geomembranes.

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