Mechanical Properties of Chemically Treated Geotextile

Md. Akhtar Hossain, Shahrin Islam

Abstract: In recent years, geotextile has been used as one of the modern technology in landfill for several functions such as geotextile filter, geotextile cushion, geotextile separator, geotextile gas vent etc. In landfills, geotextiles are subjected to a complex range of acidic and alkaline solutions generating from waste and leachate. To survive these chemical attacks in subsoil environment, geotextile is required to be enough strong and resistant. Due to the waste and leachate characteristics, it is very essential to determine the chemical resistance of geotextile used in landfills. The aim of this paper is to determine the effects of chemical aging on the tensile strength and strain of synthetic geotextile. Experimental evaluation on the properties of nonwoven polypropylene geotextile is conducted under the influence of acidic (p^H 0.5) and alkaline (p^H 14) condition. This particular p^H range signifies highly intense chemical aging. The geotextiles were immersed in the acidic and alkaline solution for 15, 30, 60, 90 and 120 days. Tensile strength and strain have been evaluated for both chemically treated samples which will provide a better understanding of the durability of geotextile to be used in landfills.

Keywords: Nonwoven Polypropylene Geotextile, Tensile Strength, Strain, Chemical Aging.

I. INTRODUCTION

In geotextile application, the long term durability is an important factor as geotextile may be used in engineering structure that is designed for 100 years or more. So, an approximate prediction of the durability of geotextile is essential under the degrading environment. In recent years, a number of researches have been conducted to determine the behaviour of various geotextile due to chemical degradation. This studies help to broaden the knowledge about the feasibility of using geotextile in landfills and mines. It is reported that, nonwoven polypropylene geotextile are used in more than 80% of all waste containment application (SI Corporation, 1996). Generally, polypropylene (PP) assumes a linear structure but due to the presence of methyl group (CH_3), it can show three different spatial arrangement such as isotactic, atactic and syndiotactic. The methyl (CH_3) side group on the polymer unit of PP creates some reactive sites along the polymer backbone by the formation of a territory carbon that results into the susceptibility of polypropylene polymer to chemical attacks (Mathur *et al.*, 1994). There are many types of nonwoven geotextiles such as needle punched, heat bounded, spin bounded, chemically adhesive etc. However, needle punched geotextile has showed the best resistance to tear, tension and puncture after being chemically treated in p^H 8 for 30-90 days under the temperature of 25 and 50 degree celsius (KA *et al.*, 2016).

Now-a-days, it has become a popular practice to use landfill for the disposal of hazardous waste. Leachates generated from such landfills possess great threats to the subsoil environment due to the existence of corrosive and radioactive wastes. The corrosive waste available in the hazardous waste are designated as the aqueous wastes with a pH less than or equal to 2.0 or greater than or equal to 12.5. Moreover, the radioactive wastes which are another forms of hazardous waste, are also present in the hazardous waste landfills. Typically the low level radioactive waste have a high pH in the range from 9-12.5 and have low concentrations of radioactive metals (Golder Associates Ltd., 1995). In this study the evaluated property of geotextile exposed to highly acidic and alkaline condition will assist to determine the competency of geotextile for application in landfill of hazardous and low level radioactive waste.

II. METHODOLOGY

The durability studies were performed on nonwoven needle-punched geotextile of polypropylene (PP) fibre. Three geotextile samples were prepared for each test by allowing them to degrade naturally in NaOH solution and HNO_3 solution. The Table 1 shows immersion condition of the prepared specimens.

Table 1: Immersion Condition on Nonwoven Polypropylene Geotextile

Solutions	Chemical Formula	p^H	Immersion Period (Days)
Nitric Acid	HNO_3	0.5	15, 30, 60, 90, 120
Sodium Hydroxide	NaOH	14	

The fabrics were washed several times with fresh water after completion of each immersion duration and subsequently, the alkali treated samples were neutralized by acid treatment and the acid treated samples were neutralized by alkali treatment to neutralize any remaining portion of acid and alkaline in the samples. Finally, the fabrics were dried at room temperature for 48 hour and then tested. The samples were tested in accordance to ASTM D5035-06 and ASTM D4632-08 on both machine direction (MD) and cross machine direction (XMD) for both grab and strip tensile strength and their corresponding elongations were also determined.

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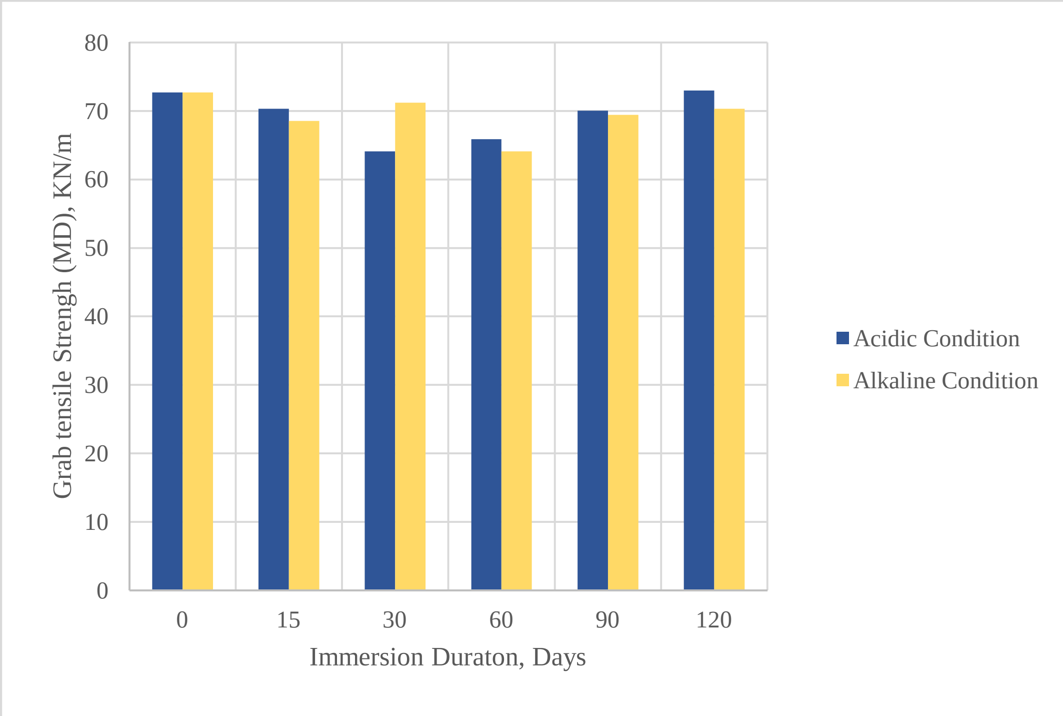
III. RESULTS AND DISCUSSION

Data obtained from the tests are plotted in the graph. Fig 1 and 2 show the effects of immersion period on grab and strip tensile strength respectively for acidic and alkaline condition. Fig 3 and 4 present the variation of strain with respect to immersion duration for both chemical conditions. Table 2 summarizes the grab tensile strengths and corresponding strains in machine and cross machine direction for acidic and alkaline condition respectively. Table 3 summarizes the strip tensile strengths and corresponding strains in machine and cross machine direction for acidic and alkaline condition respectively. Finally, fig 5 and 6 illustrated the relationship between tensile strength and strain for both grab and strip tensile test after chemical aging.



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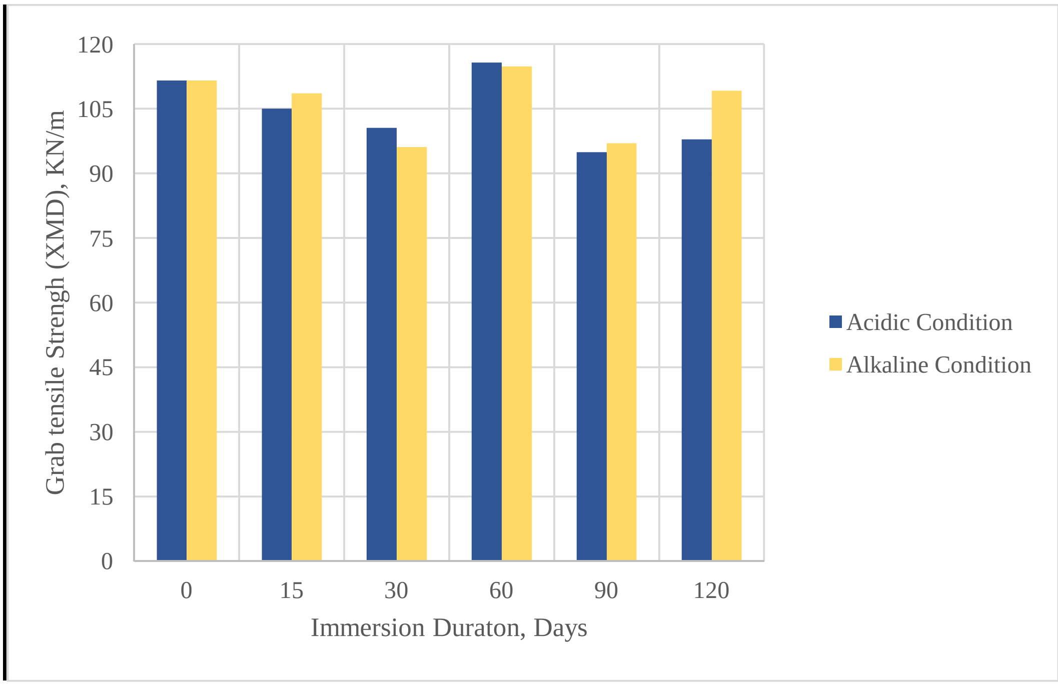

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Fig 1: Grab Tensile Strength vs Immersion Duration (a) MD (b) XMD

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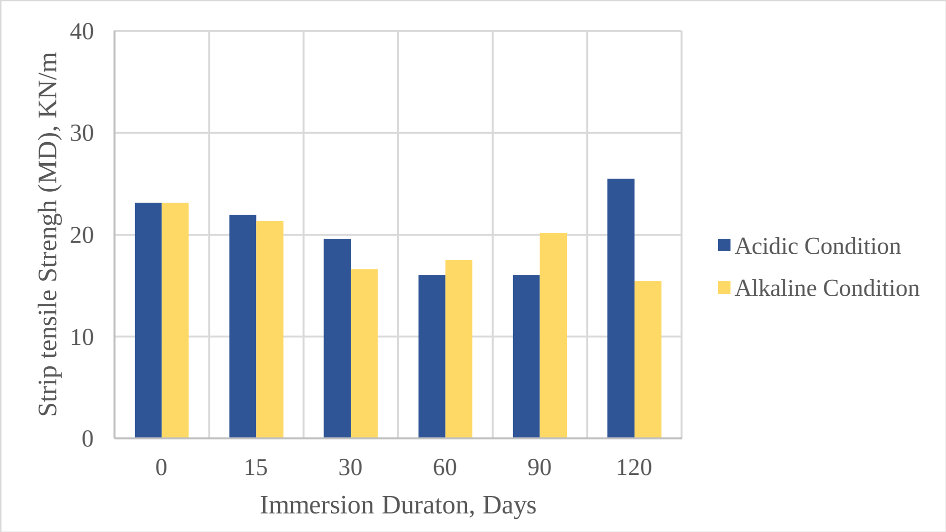

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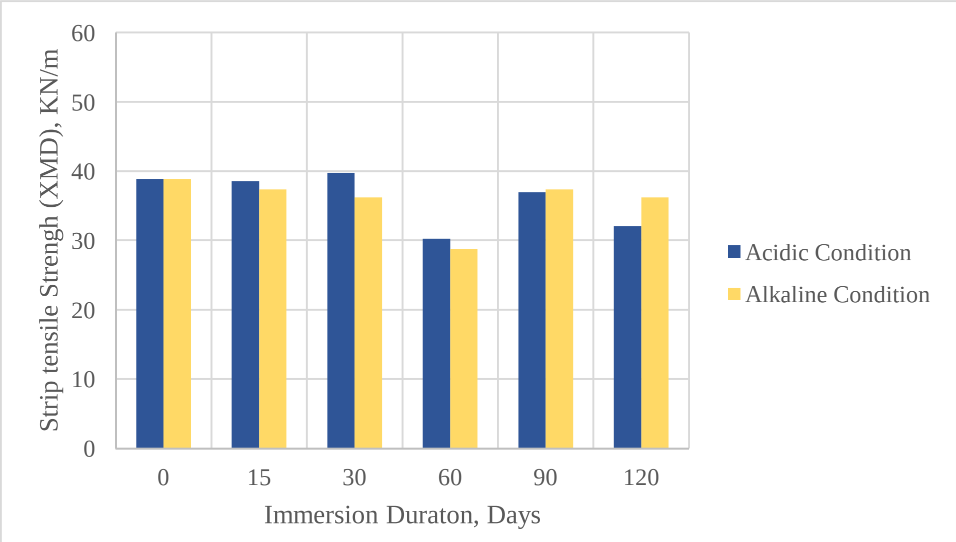

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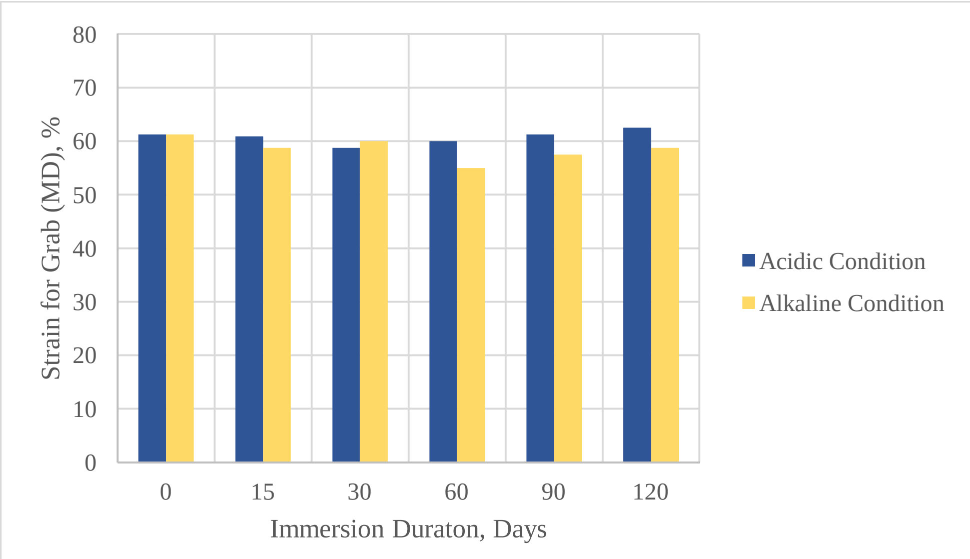
Fig 2: Strip Tensile Strength vs Immersion Duration (a) MD (b) XMD



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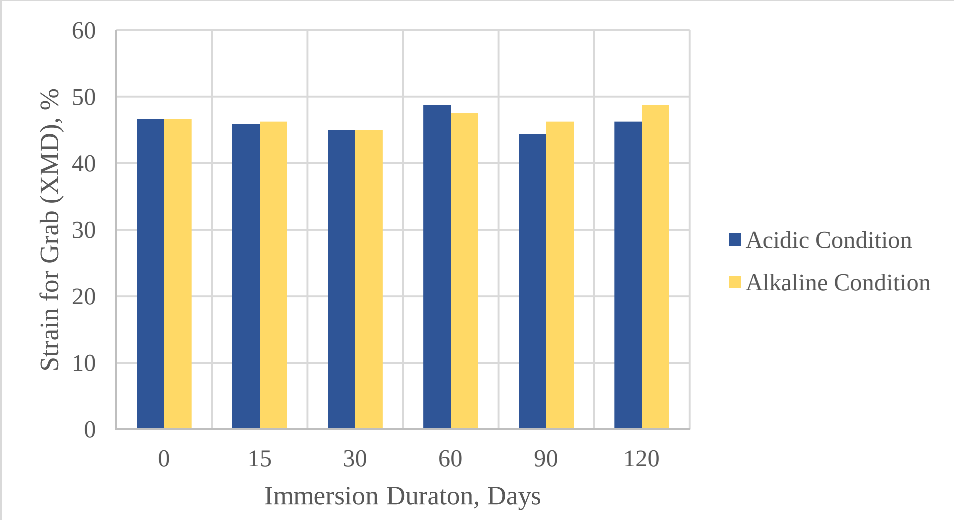

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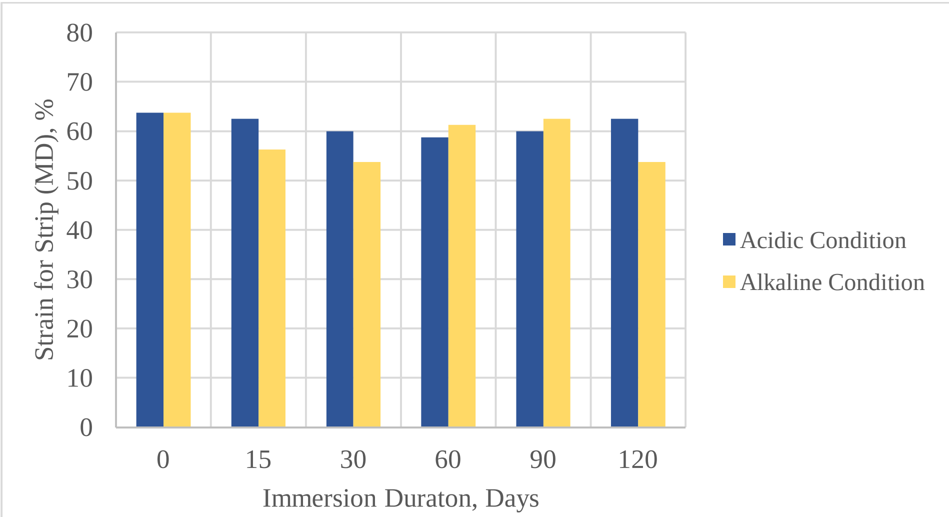
Fig 3: Strain for Grab vs Immersion Duration (a) MD (b) XMD



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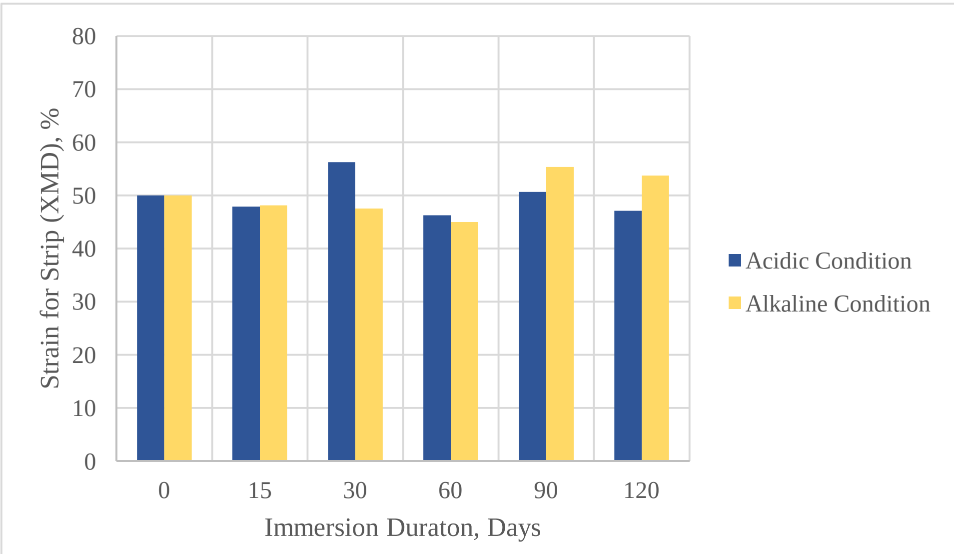

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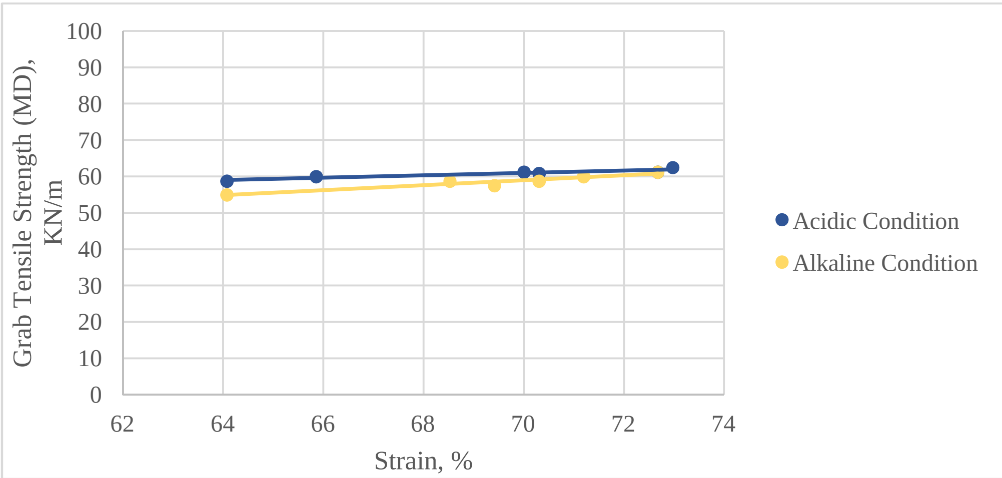
Fig 4: Strain for strip vs Immersion Duration (a) MD (b) XMD

Table 2: Grab Tensile Strength Test Results

Condition	Tensile Strength, KN/m		Strain, %	
	MD	XMD	MD	XMD
Acidic	72.68	111.55	61.25	46.63
	70.31	105.02	60.88	45.88
	64.08	100.57	58.75	45
	65.86	115.7	60	48.75
	70.01	94.93	61.25	44.38
	72.98	97.9	62.5	46.25
Alkaline	72.68	111.55	61.25	46.63
	68.53	108.58	58.75	46.25
	71.2	96.12	60	45
	64.08	114.81	55	47.5
	69.42	97.01	57.5	46.25
	70.31	109.17	58.75	48.75

Table 3: Strip Tensile Strength Test Results

Condition	Tensile Strength, KN/m		Strain, %	
	MD	XMD	MD	XMD
Acidic	23.14	38.86	63.75	50
	21.95	38.57	62.5	47.88
	19.58	39.75	60	56.25
	16.02	30.26	58.75	46.25
	16.02	36.94	60	50.63
	25.51	32.04	62.5	47.13
Alkaline	23.14	38.86	63.75	50
	21.36	37.38	56.25	48.13
	16.61	36.19	53.75	47.5
	17.5	28.78	61.25	45
	20.17	37.38	62.5	55.38
	15.43	36.19	53.75	53.75



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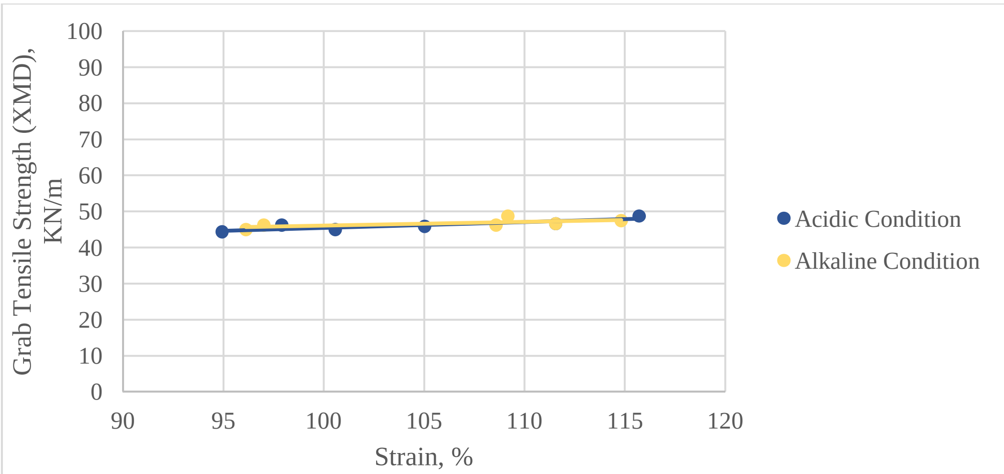

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Fig 5: Grab Tensile Strength and Strain Relationship (a) MD (b) XMD

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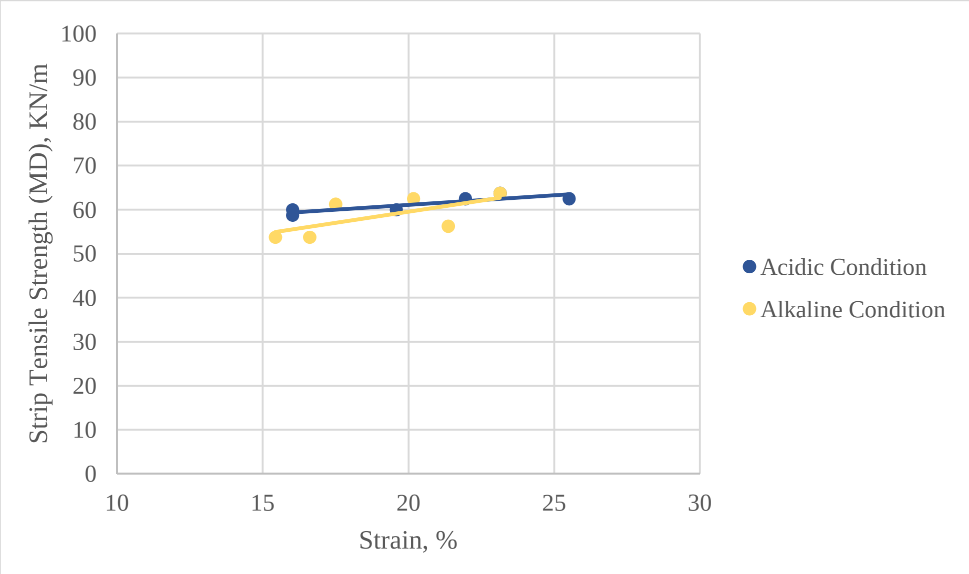

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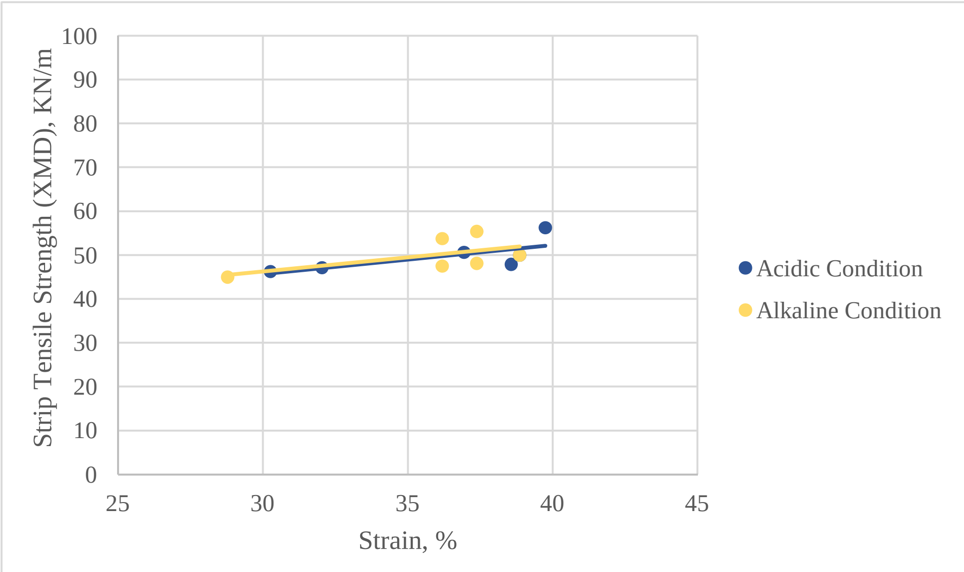

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Fig 6: Strip Tensile Strength and Strain Relationship (a) MD (b) XMD

IV. CONCLUSION

The test results show that for both acidic and alkaline conditions, tensile strengths have fluctuated for a considerable limit. For acidic condition, grab tensile strength has increased by 0.41% and decreased by 11.83% in machine direction. In cross machine direction, this strength has increased by 3.72% and decreased by 14.9%. For alkaline condition, grab tensile strength has decreased by 11.83% in machine direction with no increment. In cross machine direction this strength has increased by 2.92% and decreased by 13.83%. In case of strip tensile test, strength has risen by 10.24% and reduced by 30.77% in machine direction for acidic condition. In cross machine direction, strength has risen by 2.29% and decreased by 22.13%. For alkaline condition, strip tensile strength has reduced by 33.32% and 25.94% in machine and cross machine direction respectively without any increment in strength. So it is clear that, chemical aging has particularly more adverse effects on strip tensile strength than grab tensile of geotextile which may cause instability to the system. In strain analysis it is evident that, strain for strip tensile test has showed more fluctuation for both acidic and alkaline condition in cross machine direction than machine direction whereas fluctuations in strain values for grab tensile test are quite moderate in both directions. However, strains in all conditions have showed a proportional relation with strength. In summary, selection of geotextile for different purposes in landfills should be made taking the variations in strength and strain in consideration for the design of engineering systems to ensure stability. Finally, this study serves a better understanding of the durability of polypropylene nonwoven needle punched geotextiles that are subjected to chemical aging.

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