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Pmeasurment of different mechanical properies of fiber glass at various concentrations of different samples

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ABSTRACT

Fiber glass belongs to polymer metrics composites (PMCs). Fiberglass is widely used in the preparation of constructive materials, decorative materials, weather proofing materials, automotive parts and spares,packing materials, furniture, bus bodies, storage tanks, piping, house building, aero planes, chairs, tables, in the preparation of various instruments etc. The reason for such important applications of fiberglass is that it is hard like steel and iron materials but have advantage over these that it is not rusted. It has also low weight like plastic materials. It can also be recycled and reused. In our current study we have prepared various samples of Fiberglass by hand lay –up operation method and studied the mechanical properties of these samples using Universal Test Machine. The effect of changing concentrations of various constituents is studied.

KEYWORDS

PMCs weather proofing materials;
Plastic materials;
Universal test machine;
Concentrations.

INTRODUCTION

Fiber Glass is a composite material. Composite materials are widely used from ancient times due to their outstanding properties such as low density and cost. These materials are applied widely in automotive and aerospace industries such as bushes, seals, gears, cams, and shaft etc[1, 2]. Fiber Glass is also widely used in bus, car bodies, in preparation of various instruments, tables and chairs etc.

Fiber glass, also known as glass fiber-reinforced plastic (GFRP)[3] or Glass-reinforced plastic (GRP)[4] is a fiber reinforced polymer made of a plastic matrix reinforced by fine fibers made of glass.

The Glass fibers are composed of silica. In its pure form it is in the form of polymer (SiO2) n. It has no sharp melting point, but starts softening at 2000^0C (3632^0F). At this temperature, it also starts degradation and most of its molecules become free moving particles. After this, if it is cooled quickly, then the molecule will not be able to get an ordered structure[5]. In the polymeric form, it forms SiO4groups, which attain tetrahedral structures with silicon in center and the four oxygen atoms at the four corners of a tetrahedron.

The silica usually needs a high temperature to

be worked with it, which is a drawback of silica. Usually impurities in the form of different materials are added to the glass to lower the temperature needed for its working. These materials also impart other properties to the glass, which are beneficial in some applications. The first type of glass used for fiber was soda lime glass or A-glass. This does not show resistance to alkalis. A new type E-glass was formed; this is an alumina borosilicate glass that is Alkalis free[6]. As this type of glass is mostly affected by chemicals, such as acids, so a new type known as C-glass was introduced, this overcomes this deficiency. Glass fibers have high ratio of their surface area to their weight and this high surface area makes them more susceptible to chemical attacks. By producing air spaces between them, thermal insulation can be produced with a good thermal conductivity of 0.05w/ (m. k)[7].

Now a day E-glass is mainly used for fiberglass production all over the world. For making the glass Reinforced Plastic (GRP) or Fiber Reinforced Plastic (fiberglass), the glass is used in the form of a chopped strand mat (CSM) or a woven fabric[8]. The unsaturated polyester (using 2-butanone peroxide along with MEKP as catalyst) and Vinyl ester or epoxide compounds are used for GRP. In Fiber Glass making, the glass fiber is usually treated with a monomer or polymer and the resin, which make the material able to resist both compressive and tensile forces well[9].

The fiberglass made utensils appears just like materials made from ceramics and plastics. However the difference can be noted upon using these materials. These are stronger than plastic materials. The color of these materials is not affected by weather. It is not damaged by cold or hot weather. Upon breaking these materials can be repaired easily. These materials are less dense than other materials. These are not rusted like Iron.

The use of fiberglass made materials have also an advantage from environmental point of view. These materials can be recycled and are again used for making fiber glass materials. The recycling of fiberglass materials started at Kansas in 2009. Now a day, the Owens-Corning Corporation is using almost 40% of recycled glass as a raw material for fiberglass production[10, 11].

The materials used in fiber glass production are;

1) MEKP
2) PVA (solution)
3) Resin
4) Cobalt -Naphthenate.
5) Fiber mat (chopped strand mat).

1). MEKP or MEKPO (Methyl Ethyl Ketone per Oxide). As the name indicates is organic peroxide. It was first synthesized by a French chemist, Pierre Pastureau. MEKP is an oily liquid having no color. MEKP have less sensitivity to shock and temperature and is stable on storation[12, 13].

MEKP is an explosive material. In industry it is used in the form of solution having concentration of about 30% to 60 %. MEKP is mainly used as catalyst at room temperature. It is also used as initiator for polymerization reactions. It is not a single compound but contains almost seven isomers[14, 15, 16, 17, 18].

For the application of MEKP as catalyst, it is dissolved in dimethyl phthalate, cyclohexane or diallyl phthalate to reduce sensitivity to shock. MEKP is also skin irritant and can cause corrosive damage and also blindness if enter to the eyes. Acetone peroxide and benzoyl peroxide can be used instead of MEKP.

2). PVA (Poly Vinyl Alcohol): PVA is a cheap polymer and is been extensively used in the textile sizing, adhesives, desalination, food wrappings and oxygen resistant films[19, 20]. It exhibits important commercial applications due to its water soluble and biocompatible properties.

PVA is synthesized by the alcoholysis of poly vinyl acetate. Methanol or Ethanol is used for alcoholysis along with acid or base as catalyst. The alcoholysis in the presence of base is rapid as compared to the acid.

The procedure for PVA synthesis is the dissolution of poly vinyl acetate in alcohol, then adding the acid or base and heating. The PVA precipitates down and is thus collected. PVA is in amorphous form when unstretched. It can be drawn to a crystalline fiber. Upon heating it does not melt to athermoplastic, but at a temperature of above 150^0C, it decomposes and loss a water molecule from two adjacent hydroxyl groups.

PVA can be dissolved to water, but it is partially soluble to cold water. On heating it increases dissolution in water and can be dissolved completely in water at a temperature above 90^0C. The solution of PVA can be used again and again if it is kept free from contact with light and air, because it readily undergoes a series of reversible and irreversible gelation reactions. These reactions may increase the viscosity of solution through the formation of insoluble products[21].

3). Resin:Resin is a natural product obtained as secretions from certain plants, especially from coniferous trees. It is a viscous liquid composed of hydrocarbons. Resins are used in varnishes,in organic synthesis,in perfumes and in nail polish and produce the importance of resins in our daily life. Compounds having resins like properties are also synthesized in the laboratories and are known as synthetic resins.

Resins are chemically composed of a volatile part, mainly terpenes and in fewer amounts from non volatile solid materials which make it sticky and thick. The terpenes present in resins are; the bicyclic terpenes such as alpha pinene, beta pinene,delta-3 carene, and sabinene; the monocyclic terpenes such as limonene and terpinolene, while also some tricyclic terpenes such as sesquiterpenes,longifolene, caryophyllene and delta cardenene. The individual components of a resin are separated by fractional distillation.

Beside these components, some plants also produce resins with different constituents, especially Jeffrey Pine and Gray Pine, in the resin of which the n-heptane is present with little or no terpenes[22].

4). Co-Naphthenate:It is also known as Naphtholite. It has the ability to dry the oils and is used as oil drying agent. It is soluble in non-polar substances. It is also used as catalyst. The catalytic properties of cobalt (II) naphthenates are similar to those of related compounds containing manganese and iron. Such species are sometimes classified as active driers. Active driers are catalysts that feature redox-active metal centers. Such centers promote redox reactions with hydro peroxide-containing intermediates[23].

5). Fiber mat:It is the only solid material used in fiber glass preparation. It is present in the form of compressed sheet and is used according to the desired strength of the required fiber glass. These are of certain types having trade names such as mat-300, mat-450 and mat-600, according to their size and diameter.

Several sheets of fiber mat can also be used in fiber glass according to the strength of fiber glass sheets.

Materials and method of preparation:All the materials used in the fiber glass production, e.g. PVA, resin, cobalt/Naphthenate, MEKP and fiber mat, were purchased from a local Fiber glass shop named "Khyber Fiber Glass" which purchased these materials from "Al Kher Chemicals Industry, Lahore, Pakistan".

Preparation of composites

Different samples will be prepared by changing the weight of different constituents of fiber glass. The general methodology used is the

1). First a known amount of PVA solution, Resin, Co/Naphthenate and MEKP is taken and mixed well.
2). The prepared solution is placed on a certain mold or a clean glass sheet.
3). Fiber mat is placed on this mixture.
4). Then it is compressed to make it homogenous and the sample is allowed to become dry.

A 2% PVA aqueous Solution was prepared and that was kept free from contact with air and light, so that it can be used again and again for sample preparation. The fiber mat used was mat-450 and in each sample of fiberglass composite, the fiber mat with 90mm length and 25mm width were used. The cobalt naphthenate was added to resin in a ratio of 6g/100g. The constitution of the following three materials was changed regularly for each sample of fiberglass.

PVA solution (2% aqueous).
Resin and Co/ naphthenate solution.
MEKP.

INSTRUMENT

The instrument used was Universal test machine;

Model no 250-25CT, Serial no 250-7046, Testometric Company Limited, Lanchashire, England. The instrument was run at the maximum sensitivity of 9, with a rate of 20mm/ minute.

Experimental

The fourteen samples of fiber glass sheets were prepared by the same standard technique used for the preparation of fiber glass sheets. The amounts of these three main constituents were varied according to the table given above. The chopped strand mat used in the preparation of these samples is commonly known as, by its trade name mat-450. The mat was cut into samples of length 90 mm and width 25mm, with a weight of 1 gram each.

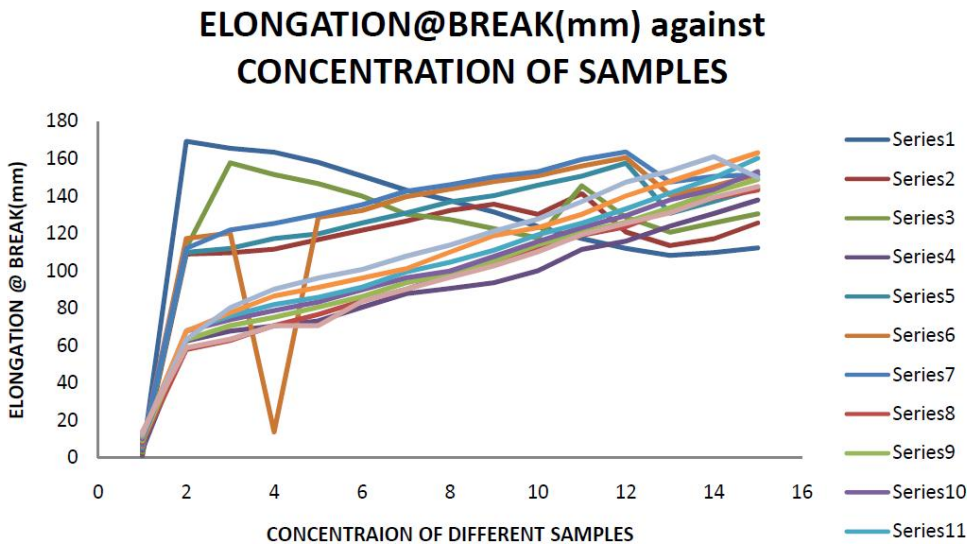
For each sample the amount of constituents were

TABLE A

Sample	PVA solution in grams	Resin and Co-naphthenate solution in grams	MEKP in grams
Sample1	0.6	0.20	0.10
Sample2	0.7	0.23	0.13
Sample3	0.8	0.26	0.13
Sample4	0.9	0.30	0.15
Sample5	1.0	0.33	0.16
Sample6	1.1	0.36	0.18
Sample7	1.2	0.40	0.20
Sample8	1.4	0.46	0.23
Sample9	1.5	0.50	0.25
Sample10	1.6	0.53	0.27
Sample11	1.7	0.56	0.28
Sample12	1.8	0.60	0.30
Sample13	1.9	0.63	0.32
Sample14	2.0	0.66	0.33

TABLE 1 : Elongation@break (mm)

S	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14
1	169.4	165.7	163.6	158.1	150.7	143.2	137.6	131.5	123.8	117.3	112.1	108.3	109.9	112.3
2	108.9	109.6	111.6	116.7	121.8	126.7	132.3	135.7	130.2	141.4	120.8	113.6	117.2	125.6
3	112.3	157.9	151.6	146.7	140.1	130.5	127.6	122.6	117.7	145.7	128.6	120.7	125.7	130.6
4	62.4	67.8	70.5	73.2	80.5	87.8	90.6	93.7	100	111.5	115.9	123.8	130.7	137.9
5	109.9	112.1	117.3	119.9	125.7	131	136.9	140.3	145.8	150.7	157.7	130.9	137.2	144.1
6	117.3	120.2	13.8	128.6	132.3	139.7	143.7	147.8	150.9	156.2	160.6	140.6	145.5	151.6
7	112.1	121.9	125.4	130.2	135.5	142.7	146.2	150.3	153.1	159.6	163.7	147.5	150.6	151.6
8	57.9	62.7	70.6	76.7	83.9	90.2	97.7	103.1	111.8	119.1	123.6	132.7	139.1	143.2
9	63.1	70.6	75.1	80.5	86.3	93.6	98.6	105.5	113.9	120.7	126.1	133.7	142.1	148.9
10	67.7	73.9	78.7	83.3	89.9	96.3	99.9	107.7	115.6	123.2	129.6	137.9	143.6	153.2
11	67.9	75.8	81.9	85.9	91.3	99.3	104.7	111.1	119.2	125.5	133.2	141.7	149.7	160.3
12	67.7	77.6	86.6	91.1	96.2	101.2	110.1	118.8	123.2	130.2	140.1	147.7	155.6	163.2
13	63.3	80.3	90.2	96.2	100.7	107.8	113.8	121.2	127.8	137.1	147.6	153.6	161.2	150.1
14	58.9	63.4	70.7	70.7	83.8	90.2	96.6	102.7	110.2	119.4	125.6	131.2	139.4	145.2



Graph 1

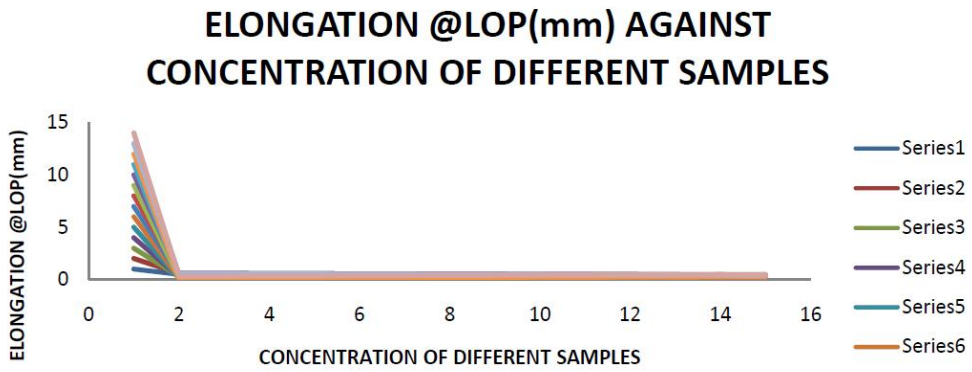
TABLE 2 : Elongation@LOP (mm)

S	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14
1	0.49	0.479	0.467	0.453	0.441	0.43	0.421	0.41	0.401	0.39	0.378	0.366	0.354	0.342
2	0.591	0.58	0.568	0.557	0.545	0.532	0.52	0.508	0.497	0.486	0.474	0.461	0.449	0.435
3	0.317	0.33	0.342	0.356	0.369	0.381	0.394	0.405	0.417	0.43	0.442	0.455	0.468	0.48
4	0.246	0.258	0.27	0.281	0.294	0.305	0.314	0.326	0.34	0.351	0.363	0.375	0.387	0.398
5	0.143	0.156	0.17	0.181	0.194	0.205	0.217	0.23	0.242	0.255	0.269	0.281	0.294	0.305
6	0.185	0.197	0.209	0.221	0.234	0.246	0.258	0.269	0.281	0.293	0.304	0.315	0.327	0.34
7	0.469	0.457	0.445	0.432	0.42	0.409	0.398	0.388	0.376	0.362	0.35	0.338	0.325	0.313
8	0.542	0.531	0.52	0.508	0.497	0.486	0.473	0.461	0.45	0.438	0.425	0.413	0.402	0.39
9	0.171	0.183	0.196	0.209	0.22	0.231	0.244	0.257	0.269	0.281	0.294	0.306	0.319	0.33
10	0.601	0.59	0.579	0.567	0.556	0.544	0.531	0.519	0.506	0.493	0.481	0.469	0.457	0.446
11	0.267	0.278	0.29	0.299	0.31	0.321	0.334	0.343	0.355	0.367	0.379	0.392	0.403	0.415
12	0.115	0.127	0.139	0.151	0.164	0.175	0.187	0.198	0.21	0.222	0.234	0.246	0.258	0.27
13	0.586	0.574	0.562	0.549	0.536	0.525	0.512	0.5	0.489	0.477	0.464	0.451	0.439	0.426
14	0.317	0.329	0.341	0.352	0.364	0.376	0.385	0.397	0.408	0.418	0.429	0.441	0.453	0.465

varied as follows.

The samples after preparation were allowed to become dry in open air. After getting dry, the samples were analyzed by Universal test machine to calculate the following properties of each sample which are listed below in the table in front of each sample.

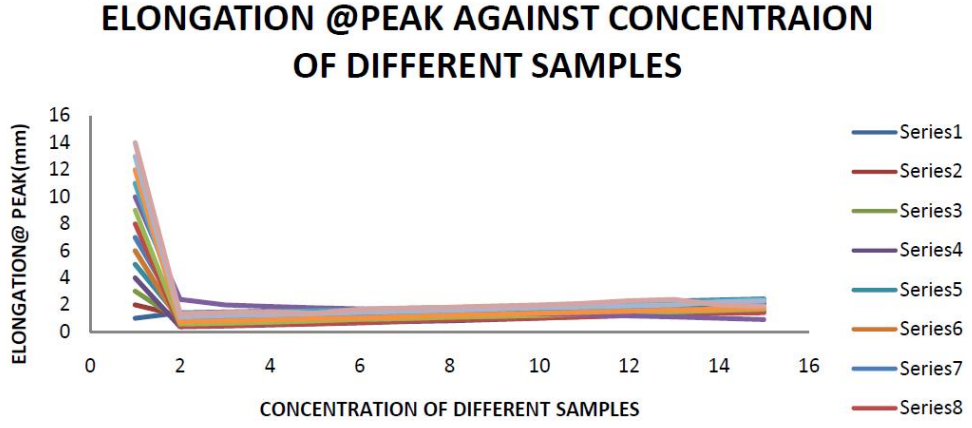
RESULTS AND DISCUSSION



Graph 2

TABLE 3 : Elongation@peak (mm)

S.NO	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14
1	1.42	1.48	1.53	1.6	1.67	1.75	1.81	1.87	1.93	1.99	2.1	2.3	2.38	2.45
2	1.21	1.28	1.35	1.43	1.52	1.59	1.67	1.75	1.82	1.89	1.95	2	2.1	2.3
3	0.8	0.9	1.01	1.17	1.23	1.29	1.36	1.43	1.55	1.61	1.67	1.76	1.89	2.1
4	0.37	0.43	0.5	0.59	0.67	0.75	0.82	0.91	1.01	1.12	1.21	1.31	1.42	1.5
5	0.98	1.1	1.18	1.24	1.31	1.38	1.47	1.54	1.62	1.73	1.82	1.91	1.99	2.1
6	0.7	0.77	0.81	0.89	0.97	1.05	1.13	1.21	1.3	1.39	1.48	1.57	1.65	1.72
7	1.32	1.39	1.45	1.52	1.61	1.69	1.77	1.83	1.9	1.98	2	2.1	2.2	2.4
8	0.41	0.47	0.56	0.61	0.71	0.8	0.89	0.95	1.02	1.11	1.22	1.29	1.38	1.41
9	0.59	0.65	0.73	0.82	0.93	0.99	1.09	1.16	1.23	1.32	1.41	1.5	1.59	1.7
10	2.4	1.99	1.87	1.79	1.71	1.62	1.53	1.42	1.34	1.27	1.19	1.1	1.01	0.91
11	1.35	1.41	1.49	1.55	1.63	1.7	1.76	1.83	1.92	1.98	2.1	2.2	2.3	2.4
12	0.73	0.81	0.88	0.96	1.02	1.11	1.22	1.29	1.37	1.45	1.52	1.61	1.67	1.75
13	1.1	1.19	1.26	1.34	1.42	1.51	1.59	1.68	1.77	1.84	1.91	1.99	2.2	2.3
14	1.33	1.43	1.49	1.37	1.65	1.75	1.82	1.91	1.99	2.1	2.3	2.4	1.99	1.9



Graph 3

TABLE 4 : Change in length=ΔV = Vf-V0

S	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14
1	3.7	2.1	5.5	7.4	7.5	5.6	6.1	2.7	6.5	5.2	3.8	1.6	2.4	5.3
2	0.7	2	5.1	5.1	4.9	5.6	3.4	5.5	8.2	12.4	6.8	3.6	8.4	10.6
3	45.6	6.3	4.9	6.6	9.6	2.9	5	4.9	28	17.7	7.9	5	4.9	2.7
4	5.4	2.7	2.7	3.3	7.3	2.8	3.1	6.3	11.5	4.4	7.9	6.9	7.2	8.5
5	2.3	5.2	2.6	5.8	5.3	5.9	3.4	5.5	4.9	7	27.2	6.3	6.9	7.7
6	2.9	6.4	7.8	3.7	7.4	4	4.1	3.1	5.3	4.4	20	4.9	6.1	7.1
7	9.8	3.5	4.8	5.3	7.2	3.5	7.5	2.8	8.5	4.1	15.8	3.1	1	0.7
8	4.8	7.9	6.1	7.2	7.2	6.3	6.9	5.4	8.7	7.3	4.5	9.1	6.4	4.1
9	7.5	4.5	5.4	5.8	7.3	5	7.8	8.4	6.8	5.4	7.6	8.4	6.8	1.6
10	6.2	4.8	4.6	6.6	6.4	6.6	6.4	7.9	7.6	6.4	8.3	5.7	9.6	3.9
11	7.9	6.1	4	5.4	8	5.4	8.7	8.1	6.3	7.8	8.5	8	10.6	2.6
12	9.9	9	4.5	5.1	5	8.9	4.1	4.4	7	9.9	7.6	7.9	7.6	2.3
13	17	8.9	6	4.5	7.1	6	7.4	7.6	9.3	10.5	6	7.6	10.9	3.3
14	4.5	7.3	6.1	6.3	6.4	6.2	6.1	6.5	9.2	6.2	4.6	8.2	4.8	3.4

TABLE 5 : Change in length/ orignal length= ΔV/V0

S	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14
1	2.18	1.26	3.36	4.68	4.97	3.91	4.43	2.05	5.25	4.43	3.38	1.47	2.18	4.71
2	6.42	1.82	4.56	4.37	4.02	4.41	2.56	4.05	6.29	8.76	5.62	3.16	7.16	8.43
3	4.06	3.98	3.23	4.49	6.85	2.22	3.91	3.99	23.78	12.14	6.14	4.14	3.89	2.06
4	8.65	3.98	3.82	4.5	11.92	3.3	5.51	5.22	28	15.87	6.81	5.57	5.5	6.06
5	2.09	4.63	2.21	4.85	4.21	4.5	2.48	3.92	3.36	4.64	17.24	4.81	5.02	5.34
6	2.47	5.32	6.3	2.87	5.59	2.86	2.85	2.09	3.51	2.81	12.45	3.48	4.19	4.68
7	8.74	2.87	3.82	4.07	5.31	2.45	2.8	1.86	5.55	2.56	9.65	2.1	0.66	0.46
8	8.29	2.87	8.64	9.38	8.58	6.98	7.67	5.23	7.78	6.12	3.64	6.85	4.6	2.86
9	11.88	6.37	7.19	7.2	8.45	5.34	6.99	7.96	6.4	4.47	6.02	6.28	4.78	1.07
10	9.25	6.49	5.84	7.92	7.11	6.85	7.8	7.33	6.57	5.19	6.4	4.13	6.88	2.54
11	11.63	8.04	4.88	6.28	8.76	5.43	6.11	7.29	5.28	6.21	6.38	5.64	7.08	1.62
12	14.62	11.59	5.19	5.59	5.19	8.79	7.9	3.96	5.68	7.6	5.42	5.34	4.88	1.4
13	26.85	11.08	6.65	4.67	7.05	5.55	6.5	6.27	7.27	7.65	4.06	4.94	6.76	2.59
14	7.64	11.51	8.62	8.91	7.63	6.87	6.31	6.39	8.34	5.19	3.66	6.25	3.44	2.34

I have taken 14 different samples in which the wt of fiber mate is taken constant 1 g in each sample. The concentration of PVA solution is taken variable in each samples in the range of (0.6M—2.0M). Resin and Co- naphthante solution range is taken from 0.20 g to 0.66g and of catalyst (MEKP) range is from 0.10 g to 0.33g. so in this way I have prepared 14 different samples. After preparation the different

TABLE 6 : %EL = 100εf = ductility

S	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14
1	2.18	1.26	3.36	4.68	4.97	3.91	4.43	2.05	5.25	4.43	3.38	1.47	2.18	4.71
2	6.42	1.82	4.56	4.37	4.02	4.41	2.56	4.05	6.29	8.76	5.62	3.16	7.16	8.43
3	4.06	3.98	3.23	4.49	6.85	2.22	3.91	3.99	23.78	12.14	6.14	4.14	3.89	2.06
4	8.65	3.98	3.82	4.5	11.92	3.3	5.51	5.22	28	15.87	6.81	5.57	5.5	6.06
5	2.09	4.63	2.21	4.85	4.21	4.5	2.48	3.92	3.36	4.64	17.24	4.81	5.02	5.34
6	2.47	5.32	6.3	2.87	5.59	2.86	2.85	2.09	3.51	2.81	12.45	3.48	4.19	4.68
7	8.74	2.87	3.82	4.07	5.31	2.45	2.8	1.86	5.55	2.56	9.65	2.1	0.66	0.46
8	8.29	2.87	8.64	9.38	8.58	6.98	7.67	5.23	7.78	6.12	3.64	6.85	4.6	2.86
9	11.88	6.37	7.19	7.2	8.45	5.34	6.99	7.96	6.4	4.47	6.02	6.28	4.78	1.07
10	9.25	6.49	5.84	7.92	7.11	6.85	7.8	7.33	6.57	5.19	6.4	4.13	6.88	2.54
11	11.63	8.04	4.88	6.28	8.76	5.43	6.11	7.29	5.28	6.21	6.38	5.64	7.08	1.62
12	14.62	11.59	5.19	5.59	5.19	8.79	7.9	3.96	5.68	7.6	5.42	5.34	4.88	1.4
13	26.85	11.08	6.65	4.67	7.05	5.55	6.5	6.27	7.27	7.65	4.06	4.94	6.76	2.59
14	7.64	11.51	8.62	8.91	7.63	6.87	6.31	6.39	8.34	5.19	3.66	6.25	3.44	2.34

samples, I checked it for different mechanical properties such as elongation@ break, elongation @LOP and elongation @ peak. The TABLE no 1 and graph no1 is taken for elongation @ break from this I have concluded that the value from R1 to R14 increases, the reason is that the increase of concentration of PVA soln, resin and Co-naphthantesoln, and MEKP occur. Which help in the quick reaction, hardness, initiate the reaction and elongation @ break also. While the value for elongation @ LOP decreases from sample R1 to R14 as shown in table and graph no 2. so it means that the concentration of different substances as discuss earlier have adverse effect on elongation@LOP. But in case of elongation@ peak, which show in table and graph no 3, have slightly increase from sample R1 to R14. there is not clear shown in the graph no 3. from all these discussion it is noted that elongation @ break and elongation@ peak have directly relationship with each other but inverse relation with elongation @LOP as shown from all the graphs 1,2,3 and TABLES 1,2,3. From all these results shown above we can calculate change in length as shown in TABLE no 4, ductility, %age elongation and so many others mechanical properties very easily.

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