EFFECT OF NATURAL QUARTZ ON THE MECHANICAL PROPERTIES OF GRP PIPES FOR WATER TRANSMISSION PIPELINES

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Abstract: Glass fiber reinforced polymer (GRP) pipe has great advantage to comparison of metallic and concrete pipe for transmission pipeline. GRP pipe is the sub-class of composite material. This paper presents, an investigation on effect of Quartz sand on the mechanical properties of composite materials. The study evaluate the tensile strength of natural quartz sand and Import quartz sand sample which manufactured by Hand lay-up method. The results demonstrate that the maximum value of Natural quartz sand improved prominently from 153 to 160 N/mm^2 compared to the value of Import quartz sand from 116 to 131 N/mm2 at 38 wt./wt. %. X-ray diffraction results reveal its crystallographic confirmation as well. Moreover, scanning electron microscope (SEM) image shows that natural quartz sand contains angular shape and fine Nano particles dispersion. While, import quartz sand contains uniform shape and coarse particle dispersion.

Keywords: *Pipe, Sand, Tensile strength, Scanning electronic microscope, X-ray diffraction*

1. Introduction

Glass Fiber reinforced polymer pipes are replace the metallic pipes because of excellent mechanical characteristics and cost-competitive compared to other types of pipe [1]. Glass Fiber Reinforced Polymer (GFRP) is a light in weight material have outstanding mechanical properties like good tensile strength, stiffness and ductility compared to carbon fiber with cheap raw materials. Generally, GFRP is one of the class of composite material which made up of two or more than two combination of different materials. When two or more heterogeneous phase materials combined to gather in which the individual components retain their separate identities as known as composite material. It has a historical background as far as third millennium BC3 when brick were manufactured by clay and straw reinforcements. Now a days, composite materials show interest toward multiple purpose due to light in weight, high corrosion resistance and good mechanical performance such as biomedical application, aerospace industry, automobiles, civil, military and packaging [2]. Composite materials have a great historical importance throughout the history of human civilization to ensuring advance future innovations [3].

The main selection of GFRP pipes in water and sewage transmission due to their pressure and gravity purpose. These are excellent corrosion resistant pipes internally as well as externally compared to concrete or metallic pipes [4]. In Glass fiber reinforcement polymer pipe, fiber is a reinforced component which is embedded in polymer as a strong load carrying material. The fibers provide tensile and circumferential strength while the resin (polymer) support to maintain structural firmness (body) [5]. Polyester resin is used to sustain broad structure load for long period of time because of formal holding, to maintain chemical and mechanical properties [2]. Also polyester resin preferred weather resistance fighter and great thermal stability for GRP pipe manufacturing and other products [6]. As for curing purpose a catalyst (usually per oxide) is add in resin which resulting in an exothermic reaction that can be initiated at ambient temperature [2]. Curing is a cross-linking reaction which convert the liquid to solid form and proper mixing of resin, gel time and temperature control offers the wide variety of mechanical properties and their performance [7]. Otherwise poor controlling on these factors may be cause of air pockets formation between surfaces and resin layer that further lead to stress rapid cracking in installation and piping systems [8].

Sand is a naturally occurring material, which is also known as “quartz sand of white sand”. Quartz sand is richer in SiO2 and also containing others impurities that vary from available rock source and weather conditions. Quartz sand is also consider harder, chemically inertness, weathering resistant and non-toxic [2]. In GRP pipe, quartz sand is used to increase wall thickness and improve stiffness for gravity application. Quartz sand is also use as a filler that improve the mechanical characteristics such tensile strength and specially stiffness and to increase the wall thickness [9]. Addition of filler such as quartz sand frequently to reduce cost and enhance to improve mechanical performance with incorporation to polymer and glass fiber [10].

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Filler enhance the great effect on mechanical properties because it has excellent ability for uniform dispersion into polymer and fiber, which make to lead strong adhesion cross-linking. Filler addition such as Al_2O_3, $Fe_2\ O_3$, Mg $(OH)_2$ and Si C was observed good tensile strength by 10 % experimentally, when compared to unfilled composite materials. As Filler content is increased, the results shows the variation in ultimate tensile strength up to 15%. Further addition of filler promote the formation of voids and weaker networking that destroy the continuous matrix network [11]. Comparative results is observed with different proportion of sand and resin composite having 5%, 10% 15% and 20 %. Whereas tensile strength and modulus value observed, 5% silica exhibit value of tensile strength 18 MPa and Young modulus value is 60 MPa. Sand content is increased up to 10%, the value of 20 MPa tensile strength and 72 MPA modulus value respectively. Further increments from 10 to 20% adversely effect on mechanical properties as value is observed, the tensile strength is 14 MPa and 60 MPa Modulus [12].

2. MATERIALS AND METHOD

Glass fiber and Polyester resin were import from Abu Dhabi and as-synthesized quartz sand import from Saudi Arabia. Indigenously sand was collected from SITE Area, Kotri**.** The Raw materials for fabrication of glass fiber reinforcement polymer are Glass fiber, Resin and Quartz sand. Quartz sand is a natural sand which is also known as white sand. At initial stage, sand washed with hot water and to heat at 110℃ for 24 hours in Oven. Prepared the required amount of resin with addition of catalyst (Cobalt) and Hardener (Methyl ethyl ketone peroxide). Cobalt (Co) accelerate the initiate reaction to convert liquid to another form and MEKP help out in solidification at ambient temperature. In this research study, concentration of Co and MEKP 2% is used whenever excessive amount concentration up to 3% will be cause of degradation for mechanical performance [13]. Resin solution is prepared into bowl which stirred very slowly and gradually. GRP composite was fabricated by hand lay-up method. Prepared the four samples of Import and Indigenously quartz sand of 3 layers GRP composite having different composition of glass fiber and sand varied respectively and resin at constant proportion by wt.%. The percentage of GF and sand was 31:34:35, 27:38:35, 23:42:35 and 19:46:35 by wt. % at constant resin percentage. Inner and outer layer was covered by glass and resin, while core part was filled with quartz sand by 11 mm wall thickness in a stainless steel frame (500×350) mm lubricant to Wax shown in figure (1 and 3) layer GRP composite kept at room temperature for solidification and furthermore fabrication of Tensile Test with standard (300×25) mm shown in figure (2).

Figure 1: Hand Lay-up Method

Figure 2: GRPCs Finished Product

3. RESULTS AND DISCUSSIONS

3.1. XRD Analysis of NQ and IQ Sand

X-ray diffraction is one of the most useful technique for the study of crystalline structure. In this technique, individual intensity of elements are being represent where as both sand having same hexagonal crystal system. All spotted peaks of NQS and IQS were analyzed by using High Score Software, Figure (3) show the all peaks of NQS as well as IQS. There are 16 NQS peaks were spotted at 2θ values of $21.2\ ^0$, 26.7^0, 35.9^0, 38.4^0, 40^0, 42^0,44^0,46, 50^0, 55^0, 60^0, 64^0, 68.5^0,70^0, 72^0 and 76^0 with planes of (100), (101), (110), (102), (111), (200), (201), (112), (003), (202), (103), (210), (211), (113), (300) and (212).Whenever 9 peaks of IQS were also spotted at 2θ value of 21.1^0, 26.9, 36.7^0, 40.7^0, 42^0, 45^0, 50^0, 60.4^0 and 66.6^0 correspond to planes (110), (101), (110), (102), (111) , (200), (201), (112) and (003).Some impurities have been found in NQS such as Ti , Fe, Mg and K at planes of (102), (112), (300). The maximum intensity of Silica have been observed in the sample NQS at 26.7^0 and IQS $26.9\ ^0$. Durawaye et al. reported that the maximum intensity of SiO_2 observed at 2θ value of 26^0 and others are as same sub-angle [14].

3.2. Tensile Strength of NQS and IQS of GFRP

In general, the tensile strength of Natural Quartz Sand samples have been found greater value compared to Import Quartz Sand of GRP composite experimentally. Four different value of tensile strength having different composition are shown in Table 1. Along study of tensile strength, the NQS have improved the tensile strength and maximum value found than IQS GRP composite samples. Furthermore, as sand content is increased, the tensile strength of IQS and NQS sample decreases. NQS have small Nano-particle size and good ability of uniform adhesion bonding than IQS. It is also observed that addition of sand content decreased the 18 % tensile strength of NQS sample whereas 22% of IQS. The maximum tensile strength of NQS and IQS have been achieved at 38% QS content as shown in figure (4).

Sr. No	Proportion of Glass, Sand and Resin (wt. /wt. %)	NQS Tensile Strength Value (N/mm^2)	IQS Tensile Strength Value (N/mm^2)
1	31:34:35 %	153	116
2	27:38:35 %	160	131
3	23:42:35 %	111	106
4	19:46:35 %	92	75

Table. 1. Composition of Glass, sand and Resin and their Tensile strength

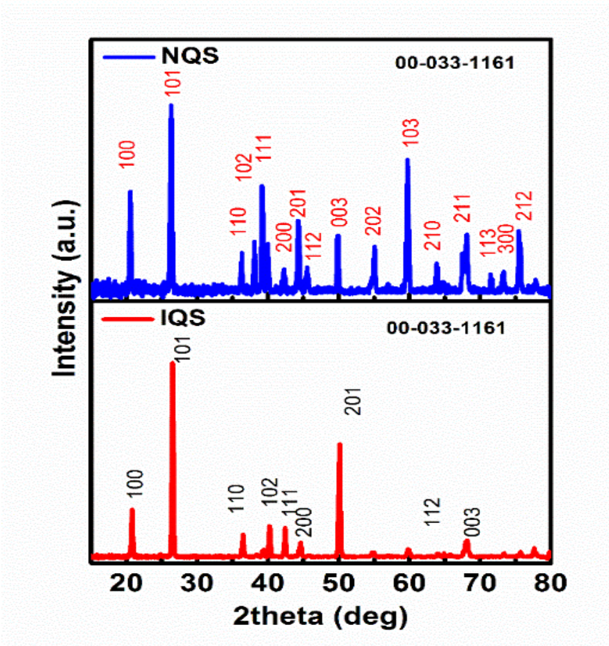

Figure 3: XRD pattern of Silica Sand

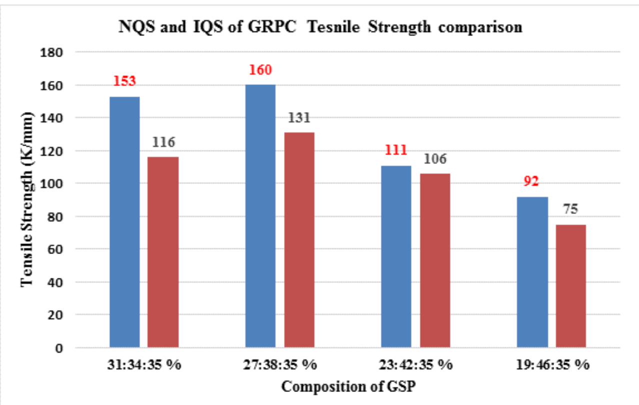

Figure 4: NQS and IQS of GRPC Tensile Strength Comparison

3.2 Surface Morphology of NQS and IQS GRPCs.

To study, the surface morphology of NQS and IQS GRP composite samples were examined under scanning electron microscope (SEM). There are some figures which show NQS sample surface morphology and of IQS sample respectively as per their proportion. Corresponding figures (6, 8, 19 and 12) of NQS and IQS with 27 /23% glass fiber surface have been observed with the same deformation angle at 100 times magnification. Whereas, in the case of sand percentage, NQS and IQS having 38 and 42 wt. % surface morphology not observed as same with magnification of 500 times as shown in figure (5,7,9 and 11). NQS morphology of surface found angular shape and IQS found uniform shape, While the Nano-Particle shape have differ. NQS Nano-Particles shape is fine than IQS particles as depicted in figure (5 and 7). Also voids and cavities are found in both samples with different manners that cause of tensile strength variation, respectively.

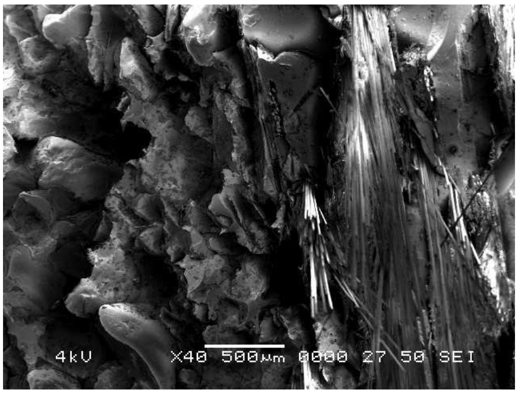

Figure 5: SEM image of NQS 38% sand sample

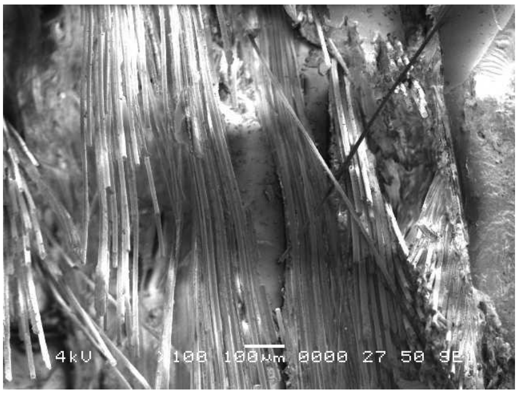

Figure 6: SEM image of NQS 27% Glass Fiber sample

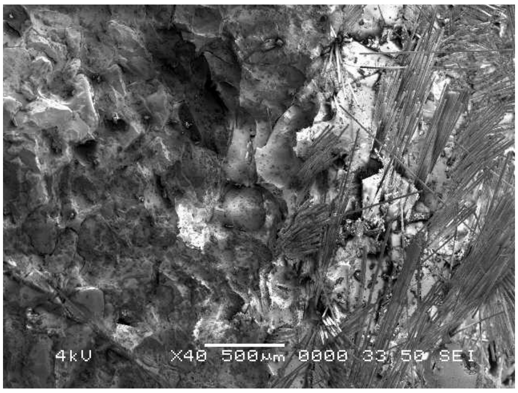

Figure 7: SEM image of NQS 42% sand Sample

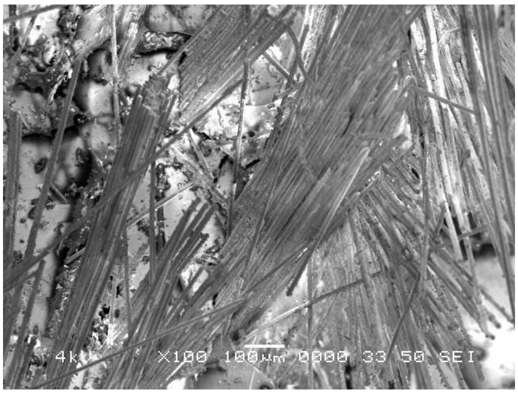

Figure 8: SEM image of IQS 23% Glass fiber sample

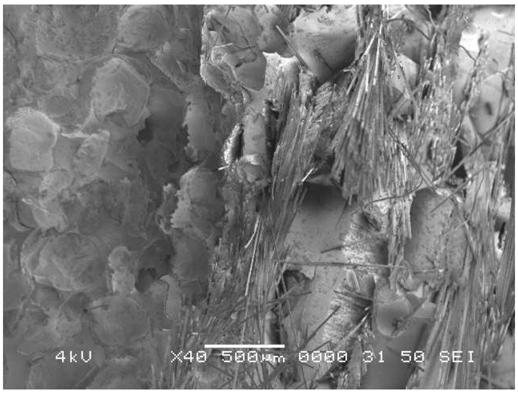

Figure 9: SEM image of IQS 38% sand

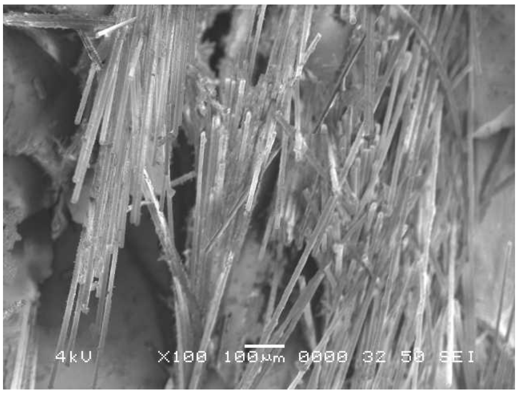

Figure 10: SEM image of IQS 27% Glass fiber

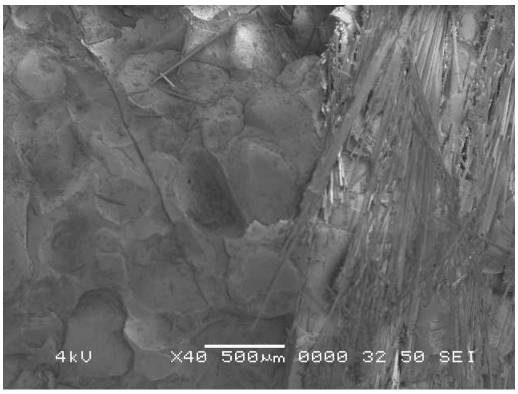

Figure 11: SEM image of IQS 42% sand

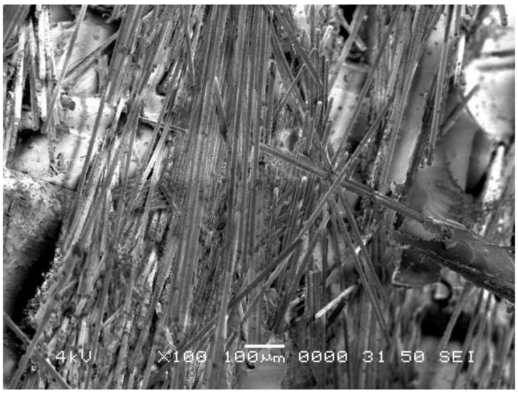

Figure 12: SEM image of IQS 23 % Glass fiber

5. Conclusion

In this study, four specimens of 3 ply GRP composite have been manufactured by Hand lay-up method with different variation in composition of natural quartz and import quartz sand. The maximum tensile strength 160 N/mm^2 of NQS sample have achieved as compared to IQS 131 N/mm^2 value 38 wt./wt.%. Whereas, as sand content has increment in the tensile strength decreased experimentally. NQS showed the great tensile strength because of its Nano-Particle size. It has been seen in SEM results that Glass fiber deformation has same angle but sand dispersion is observed in different manners. NQS image shows the angular and fine sand structure and IQS image reveals uniform with coarser particle size. By experimentally, it is analyzed that NQS improved the mechanical characteristics and can be used in the manufacturing of Glass fiber reinforced polymer pipe (GRP) application.

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