



## MECHANICAL PROPERTIES OF AMORPHOUS SILICA FILLED RSS1

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### Abstract

Rice husk contains about twenty percent silica contents. Uncontrolled burning of rice husk in the commercial incinerators leads to the crystals formation of silica which cannot be used as fillers in rubber composites. Also incomplete combustion leads to high quantity carbon black in the rice husk ash. In the current study, rice husk ash was prepared by the controlled combustion of dilute HCl treated rice husk. Controlled burning was carried out in the Rice Husk Combustor. Rice husk ash contained high percentage of white amorphous silica. Amorphous silica was mixed in RSS1 in lab scale internal mixer in various percentages. Multifunctional additives were also added in a fixed ratio to facilitate mixing and curing of RSSI. Blends were converted into uniform thickness sheets, cut into dog bone and trouser shape and were subjected to mechanical testing. TIRAtest 2810 E6 universal testing machine was used for investigation of tear and tensile characteristics. Measurement of tensile features was done by going through ASTM D412 and tear properties were investigated according to ASTM D624. Shore A type hardness meter was used to measure the hardness of Ribbed smoke sheet (RSSI) blend. It was observed that by adding amorphous silica up to 25 percent in RSSI, tensile properties and tear properties were enhanced. Only there was a decrease in tear properties after filler loading greater than 25%. Hardness was improved by addition of various percentages of amorphous silica.

**Key words:** Rice husk, RSS1 (Ribbed smoke sheet), Amorphous silica, Tensile, Tear

### 1. INTRODUCTION

Worldwide annual production of rice husk is seventy five million tons and it is a waste material. This article drives towards the solution for utilization of rice husk to make it useful product. Research shows that rice husk consists of high percentage of amorphous silica contents. Thermal energy can be obtained during burning of rice husk by using some useful methodology. The ashes obtained can give useful silica products [1]. Amorphous silica can also be produced from controlled burning process of wheat husk. It is difficult to obtain amorphous silica from commercial incinerators because incomplete combustion takes place inside masses of husks. By the treatment of wheat husk with potassium permanganate, required oxygen is provided to the husk oxidation process during burning.  $\text{KMnO}_4$  treated wheat husk is burned in tube furnace. Research shows that Potassium permanganate treated wheat husk produces amorphous silica upon burning [2].

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Treatment of rice husk with dilute solution of potassium permanganate produces amorphous silica upon burning. Thermal degradation of untreated rice husk is slower than the rice husk which is treated with  $\text{KMnO}_4$  [3]. Thermoplastic and rubber blend is called as thermoplastic elastomer and it is a fastest growing field in the polymer market. When cellulosic fillers are compounded with thermoplastic elastomers, they increase the stiffness of composites. These additives modify the interface between polymer molecules and fiber surface by introducing a linkage between them [4]. The ash of the rice husk constitutes silica and carbon as main ingredients. Carbon black and silica had been used as reinforcing fillers in natural rubber for longer period of time. Characteristics of vulcanizates which were composed of rice husk ash were analogous to those which were compounded with inert such as china clay, talcum and calcium carbonate [5]. Two forms of fillers are obtained when ash of rice husk is burnt in open air, namely (WRHA) white rice husk ash & (BRHA) black rice husk ash. About 96 % amorphous silica is present in WRHA. White ash gives maximum physical properties to natural rubber when added at optimum level. Physical properties and the curing character of white ash composed rubber blends are improved when multifunctional additives are also incorporated [6]. In the current study amorphous silica was extracted from HCl treated rice husk by the controlled combustion process in Rice Husk Combustor. This Amorphous silica was then mixed with RSS1 in various weight percentages. Tensile properties, tear properties and hardness was investigated at various weight percentages of amorphous silica.

## **2. Materials and Method**

### *2.1. Extraction of amorphous silica*

Rice husk was obtained from domestic rice mill .Pretreatment of rice husk was done with very dilute HCl solution. For this purpose 10 liter of laboratory grade HCl was added in 50 liter of water in an open drum. Rice husk was then added in this HCl solution .Rice husk was kept soaked in HCl solution for 48 hours. Wet rice husk was then dried in open air .Before subjecting to combustor it was ensured that all the water was evaporated. After complete drying, rice husk was introduced into Rice Husk Combustor where controlled combustion of the rice husk was carried out. Temperature was kept below 550 °C to avoid crystals formation. After complete combustion, Rice Husk Combustor was kept in open air for cooling. The heap of ash contained very fine, white, fluffy amorphous silica .A thin black layer of unburnt carbon was formed at the top which was swapped out easily.

### *2.2. Mixing of amorphous silica in RSS1 and sample preparation*

RSS1 (Rubber grade) was obtained from Sports Industries Development Centre. Tetramethylethiuram disulfide (TMTD), Dibenzothiazole disulfide (MBTS) and 2-Mercaptobenzothiazole (MBT) act as accelerators. Sulfur acts as crosslinking agent. These additives were obtained from local market. RSS1 and amorphous silica blend was prepared in an internal mixer of laboratory size .Conditions of mixing were as mentioned; temperature of chamber , 40°C ; speed of rotor , 40 rpm & time to mixing ,12 min. Blend weight was kept 40gm ,and amorphous silica was added in RSS1 in various weight percentages ,5% ,10% ,25%,35% and 50%. The quantity of additives was kept constant in all formulations as mentioned below.

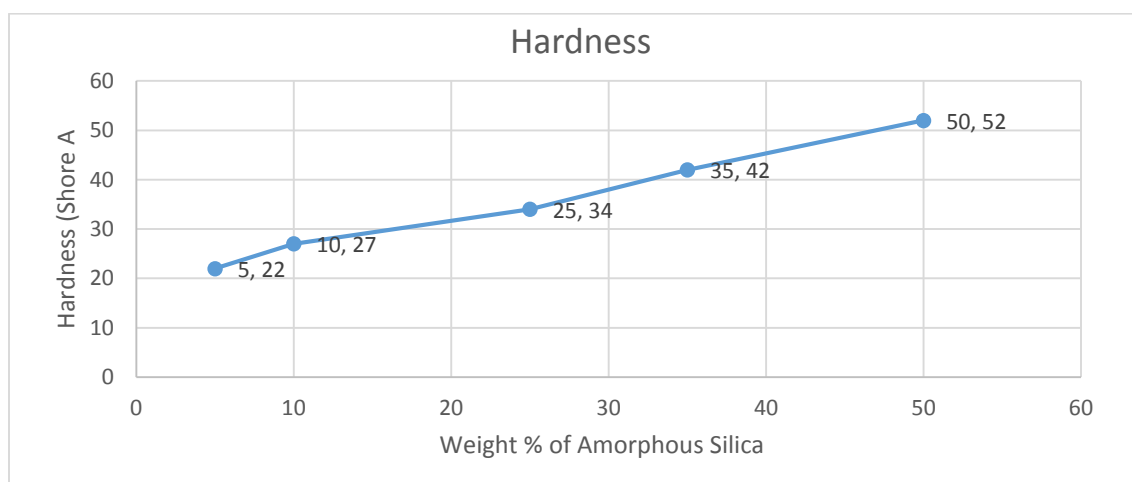
**Table 1: RSS1 Formulations**

No	Additives	Quantity(g)
1	Sulfur	0.30
2	TMTD	0.05
3	MBTS	0.08
4	MBT	0.20

The blends from internal mixer were converted into 3mm thickness sheets in the hydraulic press. Curing of RSS1 blend was carried out in the hydraulic press for 10 minutes at 150°C and 238 bar pressure. After cooling, the sheets were removed from mold and cut into dog bone shapes and trouser tear test specimen. Tensile properties were measured according to ASTM D412 and tear properties were measured according to ASTM D624 by using TIRA test 2810 E6 type universal testing machine. Hardness was measured by using Shore-A durometer.

### 3. Results and Discussion

Hardness test results against varying filler loadings are shown in the figure 1.



**Figure1. The effect of weight % of amorphous silica on hardness of RSSI blend**

Tensile strength test results obtained from universal testing machine are shown in figure 2,3,4,5 & 6. Fig 7 shows overall trend of adding amorphous silica in RSS1. Hardness and Tensile strength increases as long as % of amorphous silica is increased in RSS1. This effect is due to strong intermolecular forces between amorphous silica and RSS1 because amorphous silica have more active sites as compared with the other inert fillers used in rubber compounding. The graph in fig 7 is not exactly linear with the varying percentage of amorphous silica because of agglomeration formation during mixing of blend

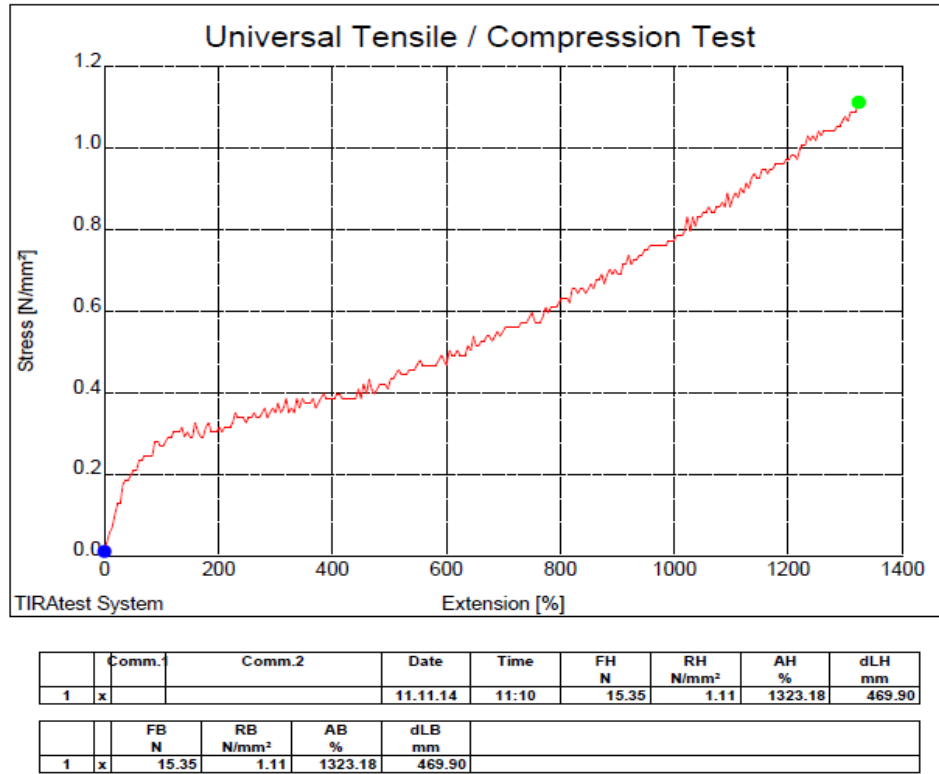


Figure2. The effect of 5% amorphous silica on tensile strength of RSSI blend

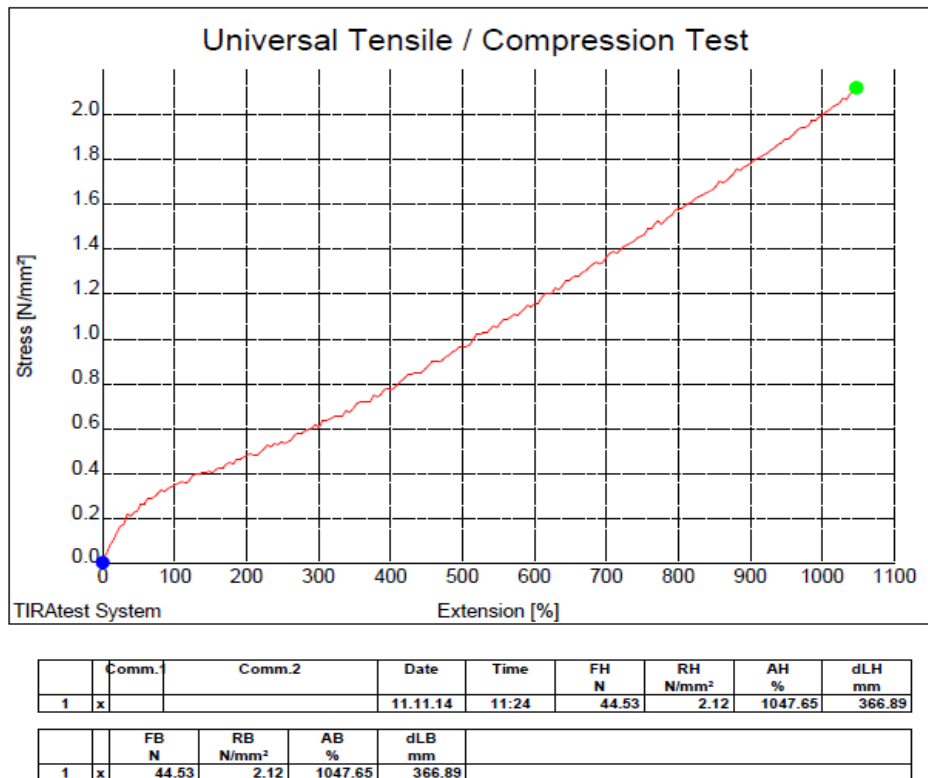
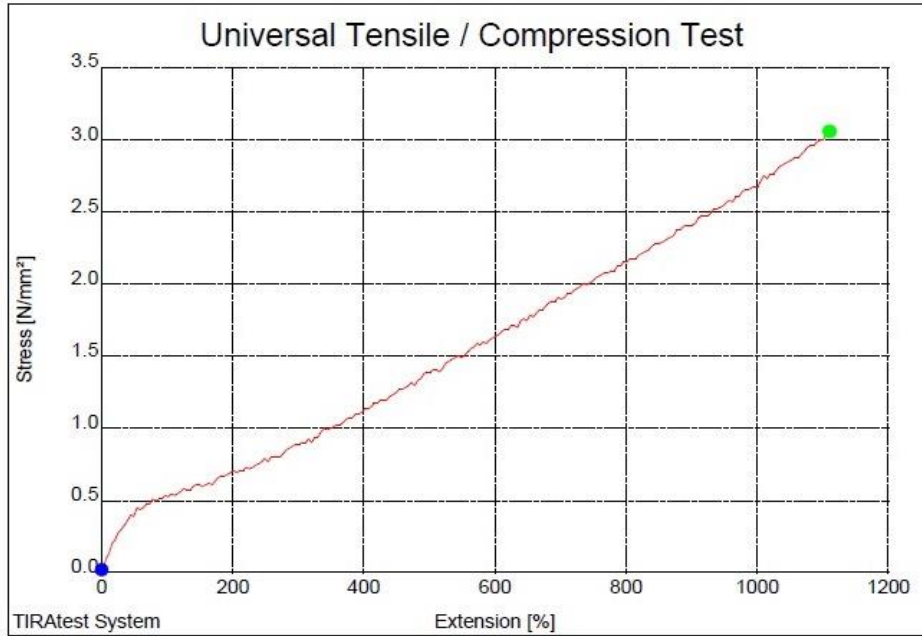


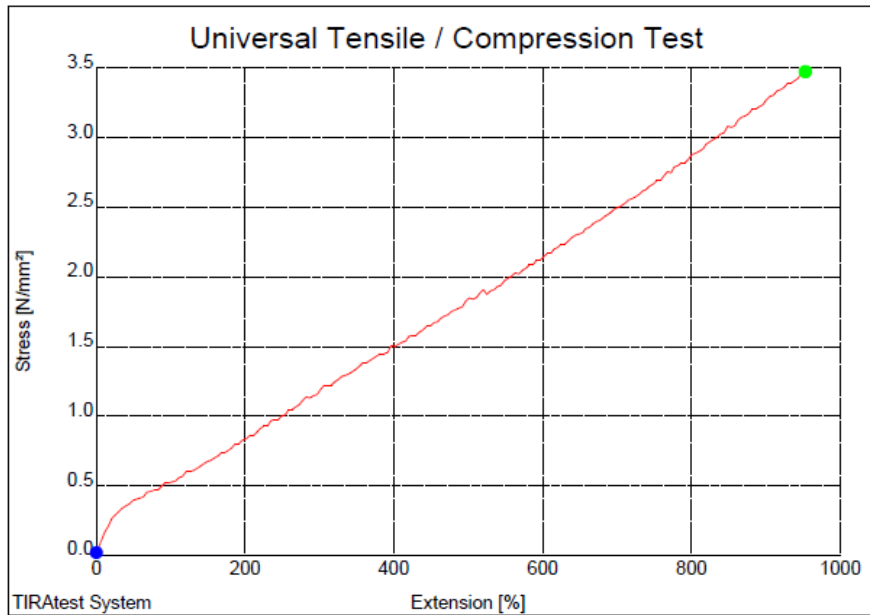
Figure3. The effect of 10% amorphous silica on tensile strength of RSSI blend



	Comm.1	Comm.2	Date	Time	FH N	RH N/mm <sup>2</sup>	AH %	dLH mm
1	x		11.11.14	11:31	40.36	3.06	1110.48	388.89

	FB N	RB N/mm <sup>2</sup>	AB %	dLB mm	
1	x	40.36	3.06	1110.48	388.89

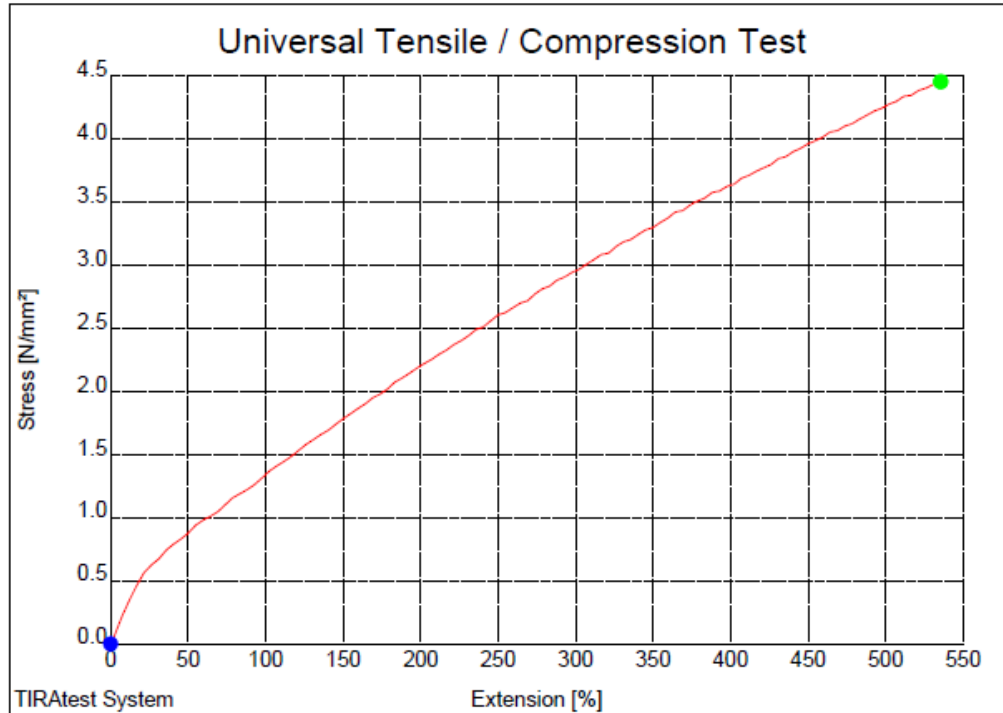
Figure4. The effect of 25% amorphous silica on tensile strength of RSSI blend



	Comm.1	Comm.2	Date	Time	FH N	RH N/mm <sup>2</sup>	AH %	dLH mm
1	x		11.11.14	11:47	68.77	3.47	953.42	333.89

	FB N	RB N/mm <sup>2</sup>	AB %	dLB mm	
1	x	68.77	3.47	953.42	333.89

Figure5. The effect of 35% amorphous silica on tensile strength of RSSI blend



	Comm.1	Comm.2	Date	Time	FH N	RH N/mm²	AH %	dLH mm
1	x		11.11.14	11:51	106.83	4.45	535.57	187.56

	FB N	RB N/mm²	AB %	dLB mm	
1	x	106.83	4.45	535.57	187.56

Figure6. The effect of 50% amorphous silica on tensile strength of RSSI blend

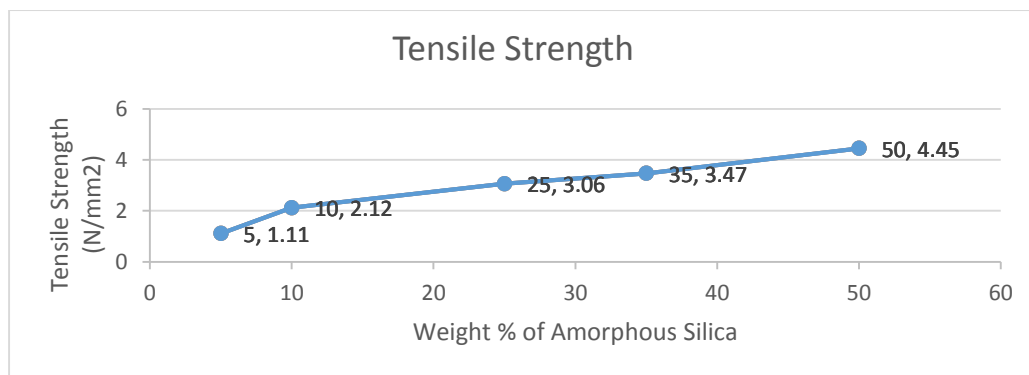
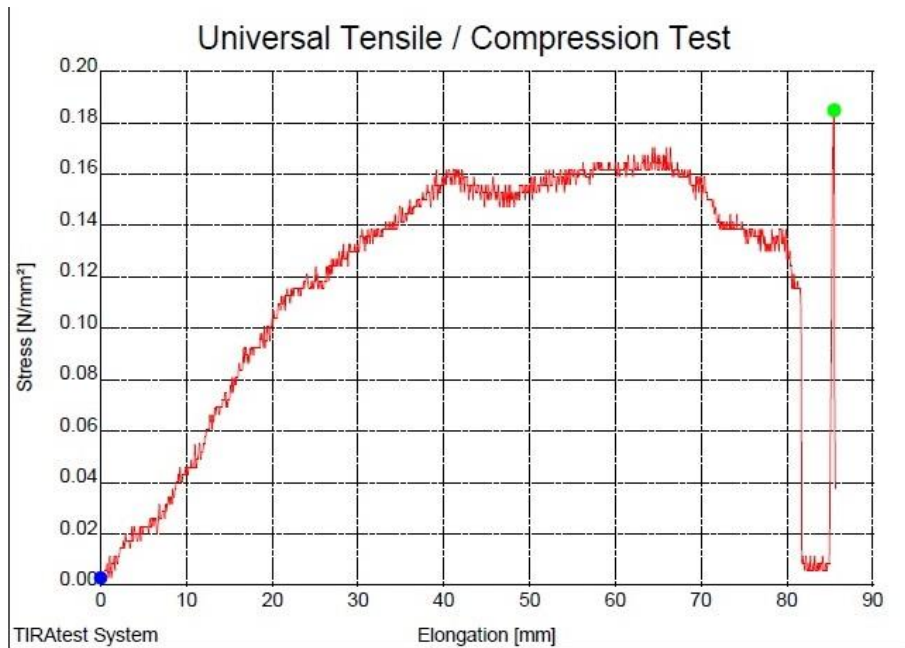


Figure7. Trend analysis of Tensile strength and weight % of Amorphous Silica

Test results of tear strength obtained from UTM are shown in the fig 8, 9, 10, 11&12 .The overall trend of filler loading on tear properties is shown in fig 13. Tear strength increases with increase of filler loading, reaches a maximum value then starts decreasing .After 25% filler loading there is a decrease in tear strength .This happened due to poor mixing of amorphous silica in RSS1 blend. The poor mixing caused reduced

interaction between amorphous silica and RSS1 at some locations and caused the test specimen to tear at low stress.



	Comm.1	Comm.2	Date	Time	FH N	RH N/mm <sup>2</sup>	AH %	dLH mm
1	x		11.11.14	12:05	10.34	0.18	61171.20	85.50

	FB N	RB N/mm <sup>2</sup>	AB %	dLB mm	
1	x	10.34	0.18	61171.20	85.50

Figure8. The effect of 5% amorphous silica on tear strength of RSSI blend

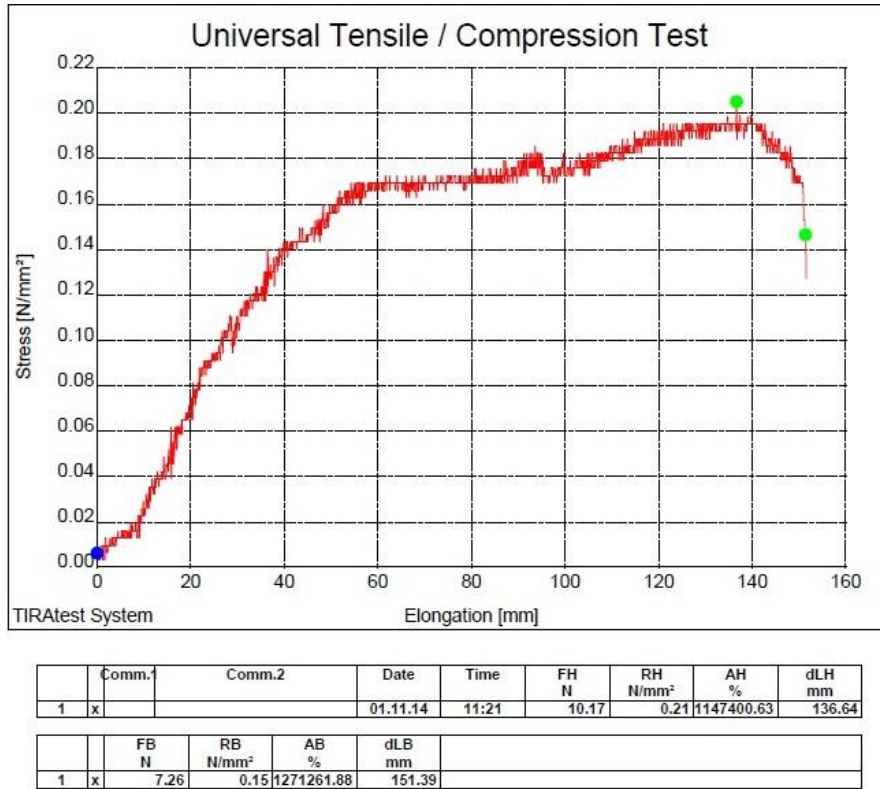


Figure9. The effect of 10% amorphous silica on tear strength of RSSI blend

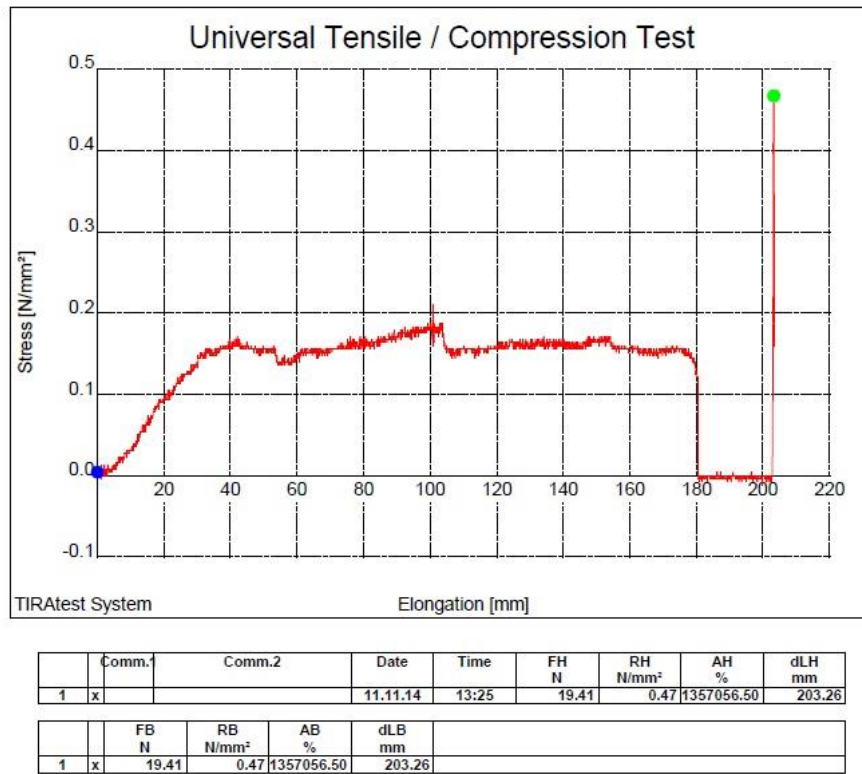


Figure10. The effect of 25% amorphous silica on tear strength of RSSI blend



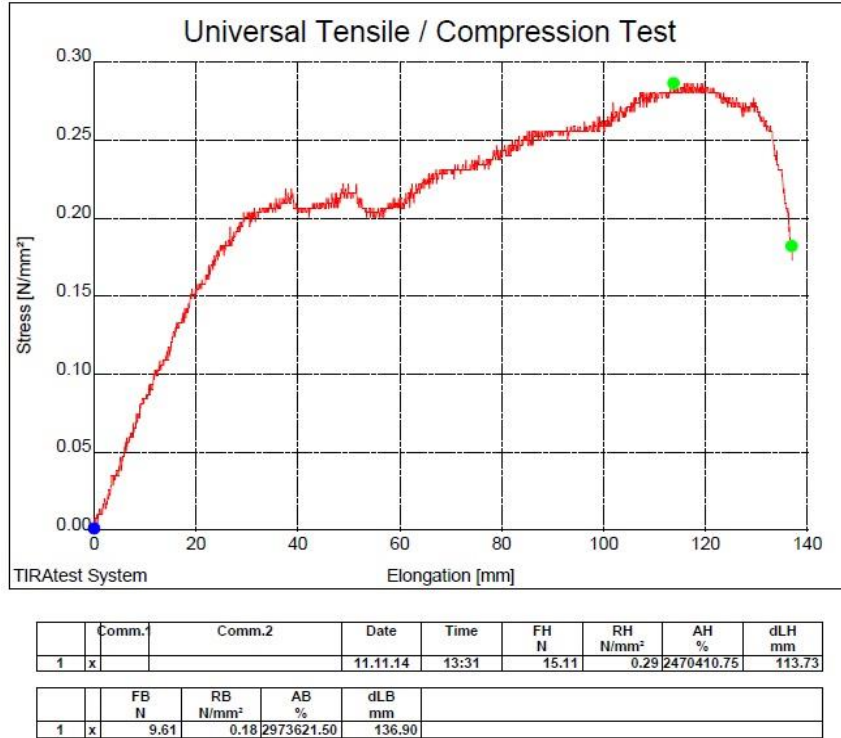


Figure11. The effect of 35% amorphous silica on tear strength of RSSI blend

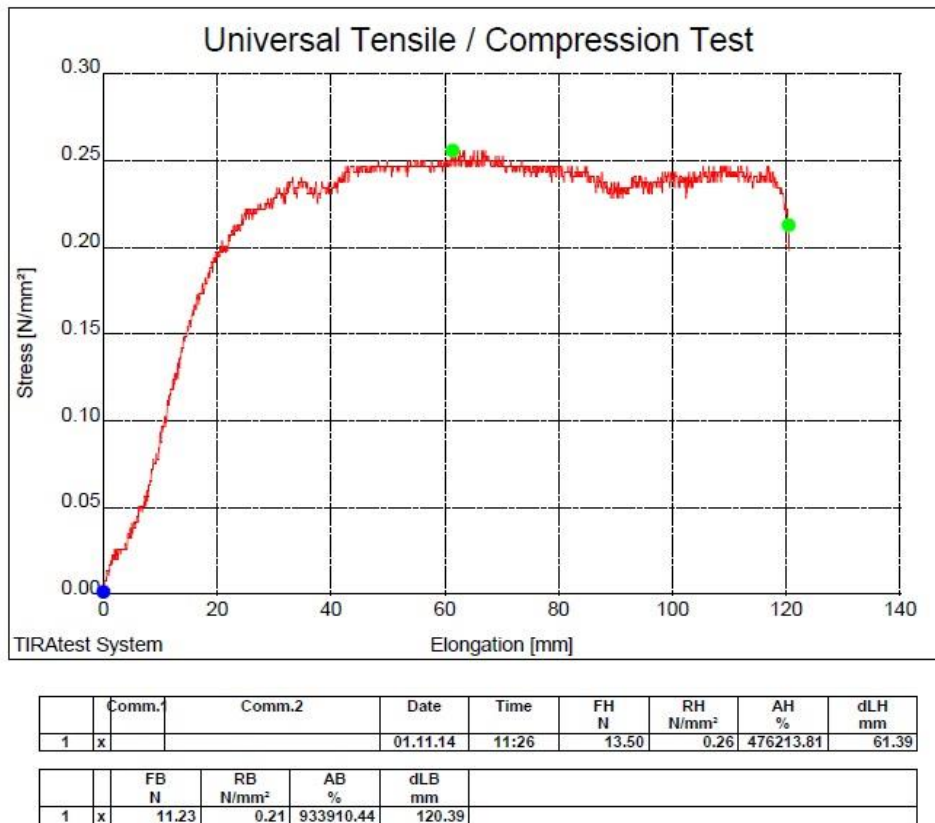
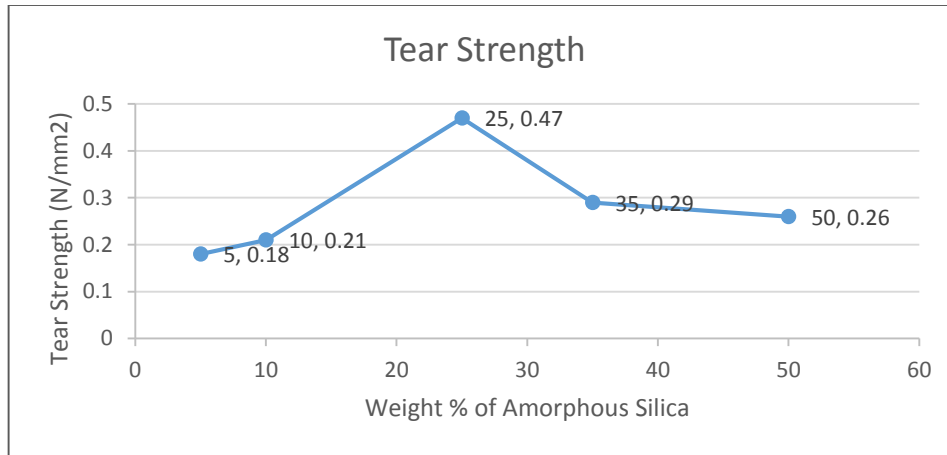


Figure12. The effect of 50% amorphous silica on tear strength of RSSI blend



**Figure13. Trend analysis of Tear strength and weight % of Amorphous Silica**

In the above graphs, FH is the maximum force .RH is the tensile force .AH is the overall extension on highest force. Elongation at highest force is denoted by dLH. FB signifies breaking force .Stress at break is RB. Overall extension at break is AB & dLB is the elongation at break.

#### 4. Conclusion

Pretreatment of rice hulls by dilute hydrochloric acid solution created cell burning .It facilitated the combustion process in rice husk combustor and as a result, white fluffy rice husk ash was obtained which consisted high percentage of amorphous silica. When amorphous silica was added to a certain level in RSS1, tensile characteristics, tear properties and hardness of the blend were increased.

#### 5. Acknowledgement

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