

A Study on Soil Improvement by Using Rice Husk and Bentonite

Mudo Puming¹, Dr.Monowar Hussain², Geli Basar³, Moby Nikang⁴

Assistant Professor, Department of Civil Engineering, NERIST, Nirjuli, Arunachal Pradesh, India¹

Assistant Professor, Department of Civil Engineering, NIT, Silchar, Assam, India²

UG Student, Department of Civil Engineering, NERIST, Nirjuli, Arunachal Pradesh, India³

UG Student, Department of Civil Engineering, NERIST, Nirjuli, Arunachal Pradesh, India⁴

ABSTRACT: Rice husk disposal has been one of the major concern of the global-world as it is produced in large amount due to rice being staple food of many country. By keeping this idea, our project aims to solve the problem of proper disposal of rice husk by burning it and then using its ash as an admixture with soil there by simultaneously contributing to the study in improvement of the geotechnical properties of soil. Rice husk being biodegradable in nature will decompose and would cease to contribute to any change in the properties of soil if used in its raw form. Hence, it was required to use the ash of Rice husk (RHA). RHA content in the soil were varied from 10, 15 and 20%. As RHA alone lacks binding property hence, bentonite was used along with RHA in the study of soil properties. Bentonite content was also varied from 10, 15 and 20%. Laboratory experiments to check the basic geotechnical properties of soil like permeability, proctor test, Atterbergs limit and direct shear test were conducted. The research outcome shows that RHA and bentonite when used together can improve the strength property of the locally available sandy soil. Although use of RHA alone can greatly decrease the plasticity index of sandy soil but it could be concluded that the use of RHA may be very helpful for clay type of soil.

KEYWORDS: Soil improvement, Rice husk, Rice Husk Ash, admixture, bentonite, strength of soil, plasticity of soil.

I. INTRODUCTION

Soil is one of the most important engineering materials. The geotechnical properties of a soil such as its grain-size distribution, plasticity, permeability and shear strength etc. can be assessed by proper laboratory testing. Soil alone has very specific properties that may not be appropriate for different types of constructions. Thus admixtures are necessary to improve the geotechnical properties of soil. Use of admixtures is one way of modifying soil properties. Use of bentonite^[1] can be very effective in increasing plasticity of a soil. Rice Husk Ash (RHA) is a carbon neutral green product. Disposal of Rice husk has encountered different constrains. Thus, in this work an attempt is made to make use of this product to improve different properties of soil. Bentonite^[2] is a highly expansive soil. It exhibits a tendency of swelling on coming in contact with water and shrinks on removal of water. In case of bentonite, free swelling is upto ten times to fifteen times to its original volume. Bentonite clay is a unique clay due to its ability to produce an electrical charge when hydrated. Upon contact with fluid, its electrical components changes giving it the ability to absorb toxins. Bentonite is known for its ability to absorb and remove toxins, heavy metals, impurities, and ^[3]chemicals. Over the times, cement and lime are the two main materials used for stabilizing soils. These materials have rapidly increased in price due to the sharp increase in the cost of energy. Thus the use of agricultural waste such as rice husk will considerably reduce the cost. Rice husk is an agricultural waste obtained from milling of rice. About 108 tons of rice husk is generated annually in the world. Hence, use of Rice Husk for improvement of soil property should be encouraged. Rice husk ash (RHA) is a by-product from the burning of rice husk. Burning of rice husk generates about 15-20% of its weight as ash. Rice husk is extremely prevalent in East and South-East Asia because of the rice production in this area. Meanwhile, the ash has been categorized under pozzolana, with about 67-70% silica and about 4.9% and 0.95%, alumina and iron oxides, respectively. And ^[8,10]silica is a very good admixture to increase the soil

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

strength. The high percentage of silicious materials in the RHA makes it an excellent material for soil stabilization. Also high percentage of silica reduces the plasticity of clayey soils. Bentonite^[12] is an absorbent clay consisting mostly of montmorillonite mineral. The different types of bentonite are each named after the respective dominant element, such as potassium(K), sodium(Na), calcium (Ca), and aluminium (Al). The type of bentonite we used for the project is a Sodium bentonite. Sodium bentonite expands when wet, absorbing as much as several times its dry mass in water. In this work, the soil used was a locally available sandy soil and sandy soil when dry being porous in nature contains lots of pores in it. Bentonite on the other hand fills these pores.

II. LITERATURE REVIEW

Some of the important literatures reviewed are :

Brooks^[4] et.al (2009) carried out experiments to study the effect of mixing RHA with bentonite in an effort to upgrade it as a construction material. From his experimental work he came to the conclusion as: Stress strain behavior of unconfined compressive strength showed that failure stress and strains increased by 106% and 50% respectively when the RHA content was increased from 0 to 25%. When the RHA content was increased from 0 to 12%, Unconfined Compressive Stress increased by 97%. When the RHA content was increased from 0 to 12%, CBR improved by 47%. The optimum RHA content was found at 12% for both UCS and CBR tests. **B.Suneel^[5] et.al** (2014) studied the behaviour of Clayey Soil Stabilized with Rice Husk Ash. Rice Husk Ash (RHA) which was mixed with soil to study improvement of weak sub grade in terms of compaction and strength characteristics. Silica produced from rice husk ashes was found to be successful as a pozzolanic material in soil stabilization. **Dilip^[6] et.al** (2004) made the research on effect of rice husk ash(RHA) on engineering properties of black cotton soil. From the results of the investigation carried out by them the conclusion was made as: With the increase in Rice husk ash percentage the Optimum moisture content increases from 18.25% to 22.00%. Maximum dry density decreases from 1.68gm/cm³ to 1.51 gm/cm³. There is significant increase in the values of California bearing ratio and Unconfined Compressive Strength. California bearing ratio increases from 1.94% to 7.52% and Unconfined strength increases from 1.10 Kg/cm² to 1.43Kg/cm². **Kumar^[7] et.al** (2012) has work on properties and industrial application of rice husk. Rice husk has been used directly or in the form of ash either as a value added material for manufacturing and synthesizing new materials or as a low cost substitute material for modifying the properties of existing products. Presence of silica is an additional advantage in comparison to other by-product materials which makes RH an important material for a wide range of manufacturing and application oriented processes. Easy availability and low price of rice husk in rice producing countries is an extra benefit towards the use of this material. **Mohammed Y. Fattah^[9] et.al** (2012) conducted the test on Improvement of Clayey Soil characteristics using Rice Husk Ash. From the results of the investigation carried out the conclusion made was: The liquid limit of the three soils has been decreased by about (11-18)% with the addition of 9% RHA, while the plasticity index decreased by about (32-80)%. Treatment with rice husk showed a general reduction in the maximum dry unit weight with increase in the rice husk content to minimum values at 9% rice husk content. The optimum moisture content generally increased with increase in the RHA content. There is enormous increase in the unconfined compressive strength with increase in rice husk content for the soil to its maximum at RHA between (6-8)%. **Roy^[12]** (2014) studied the soil stabilization by rice husk ash (RHA). The soil sample used for this study is collected from local area at Burdwan in West Bengal, India at a depth of 1.5m to 2.5m using the method of disturbed sampling. The RHA was collected from Bishalakshi Rice Mill at Burdwan. The RHA was ground and sieved through 0.075mm aperture before use. From the results of his studies on soil stabilization by RHA, the conclusions drawn were: Treatment with RHA and a small percentage of cement shows a general decrease in the MDD and increase in OMC with increase in the RHA content. There is also an improvement in the unsoaked CBR 106% at 10% RHA compared with the CBR of the natural soil. A similar trend is obtained for UCS. The UCS value is at its peak at 10% RHA (90.6% improved). For maximum improvement in strength, soil stabilization using 10% RHA content is recommended as optimum amount for practical purposes.

III. MATERIAL AND METHOD

The soil sample was collected locally from dumping site at Itanagar, Arunachal Pradesh. Rice Husk required was collected from a local rice mill. Rice husk was open burnt to convert into Rice Husk Ash (RHA). Bentonite used is

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

Sodium bentonite. Standard Procedures^[13] were followed while conducting different laboratory experiments conducted were falling head permeability test, proctor test, plastic limit, liquid limit, shrinkage limit and direct shear test.

IV. EXPERIMENTAL RESULTS

(I) FALLING HEAD PERMEABILITY TEST

Sl.No.	Sample Combination	Coefficient of permeability (cm/s), k
1	100% Soil	1.86×10^{-3}
2	80%S+10%RHA+10%B	1.43×10^{-3}
3	70%S+15%RHA+15%B	2.45×10^{-3}
4	60%S+20%RHA+20%B	4.74×10^{-3}

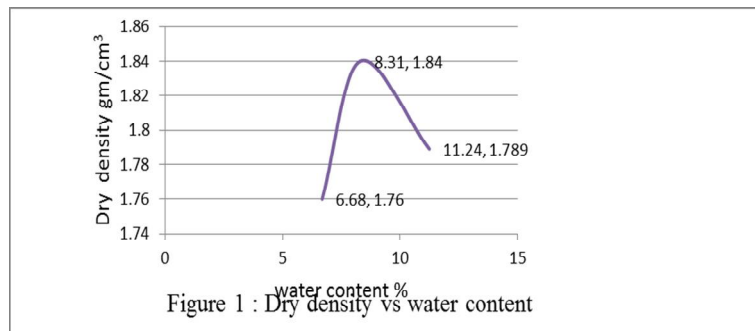
Table-I: Coefficient of permeability obtained for different combination of sample

(II) PROCTOR TEST

(i) 100% Soil

Sl. no.	mass of compacted soil (kg), m	water content (%)	bulk density (gm/cm^3), ρ	dry density (gm/cm^3), ρ_d
1	1.88	6.68	1.88	1.76
2	1.78	8.31	1.78	1.84
3	1.99	11.24	1.99	1.789

Table-II: Dry density and water content obtained for 100% Soil



Graph-I: OMC = 8.31%, Dry density = $1.84 \text{ gm}/\text{cm}^3$

(ii) 80% S+10% RHA+10% B

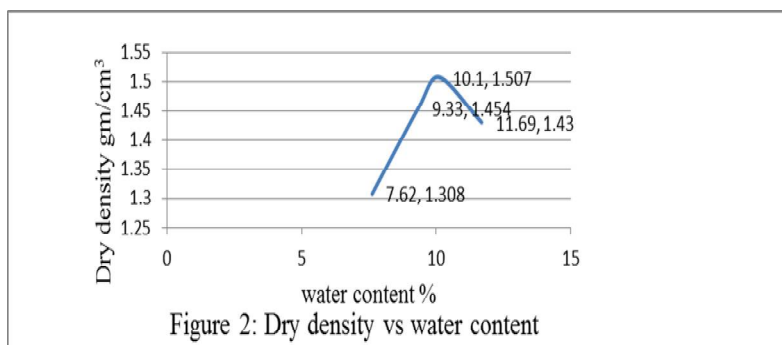
Sl. no.	mass of compacted soil (kg), m	water content (%)	bulk density (gm/cm^3), ρ	dry density (gm/cm^3), ρ_d
1	1.5	14.62	1.5	1.308
2	1.59	9.33	1.59	1.454
3	1.66	10.1	1.66	1.507
4	1.66	11.69	1.66	1.49

Table-III: Dry density and water content obtained for 80% S+10% RHA+10% B

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

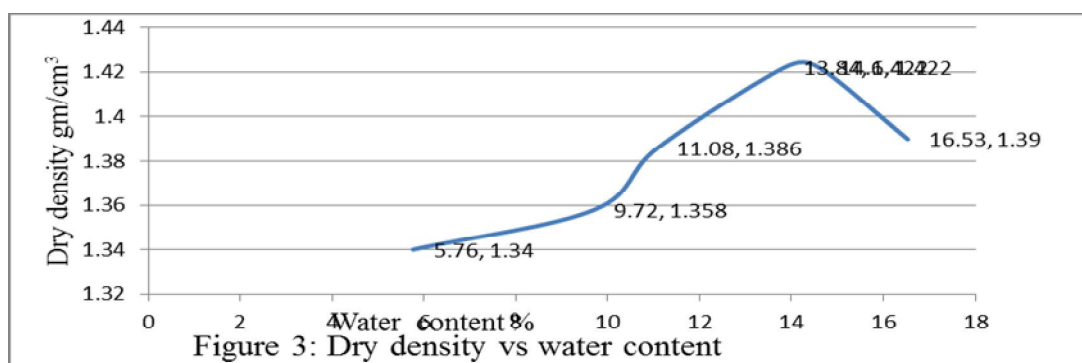


Graph-II: OMC = 10.1%, Dry density = 1.5 gm/cm³

(iii) 70% S+15% RHA+15% B

Sl. no.	mass of compacted soil (kg), m	Water Content (%)	bulk density (gm/cm ³), ρ	dry density (gm/cm ³), ρ _d
1	1.42	5.76	1.42	1.34
2	1.49	9.72	1.49	1.358
3	1.54	11.08	1.54	1.386
4	1.62	13.84	1.62	1.422
5	1.63	14.6	1.63	1.422
6	1.62	16.53	1.62	1.39

Table-IV: Dry density and water content obtained for 70% S+15% RHA+15% B



Graph-III: OMC = 13.84%, Dry density = 1.422 gm/cm³

(iv) 60% S+20% RHA+20% B

Sl. no.	mass of compacted soil (kg), m	Water Content, (%)	bulk density (gm/cm ³), ρ	dry density (gm/cm ³), ρ _d
1	1.2	7.11	1.2	1.08
2	1.32	8.35	1.32	1.196
3	1.39	10.55	1.39	1.257
4	1.34	13.93	1.34	1.175

Table-V: Dry density and water content obtained for 60% S+20% RHA+20% B

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

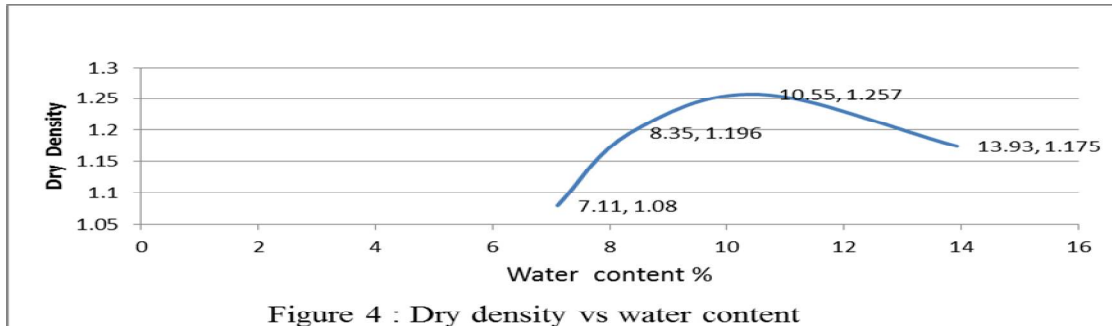


Figure 4 : Dry density vs water content
Graph-IV: OMC=10.55%, Dry density = 1.25gm/cm³

(III) PLASTIC LIMIT

Sl. No.	Sample Combination	Plastic limit
1	100% Soil	0.00%
2	80%S+10%RHA+10%B	0.00%
3	70%S+15%RHA+15%B	32.35 %
4	60%S+20%RHA+20%B	30.69 %

Table-V: Plastic limit obtained for different combination of sample

(IV) SHRINKAGE LIMIT

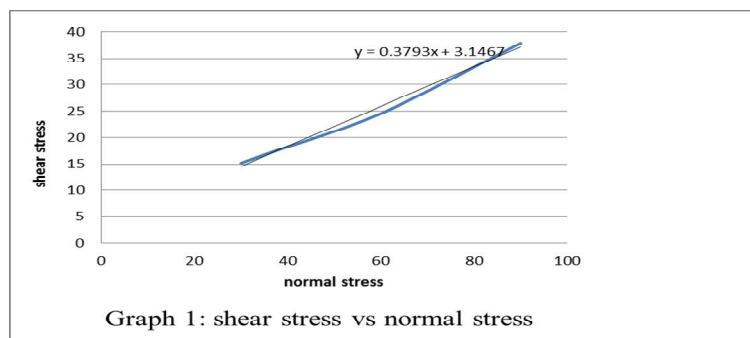
Sl. No.	Sample Combination	Shrinkage Limit%
1	100% Soil	24.9
2	80%S+10%RHA+10%B	18.65
3	70%S+15%RHA+15%B	13.13
4	60%S+20%RHA+20%B	14.66

Table-VII: Shrinkage Limit% obtained for different combination of samples

(V) DIRECT SHEAR TEST

(i) 100% S

Sl.No.	Shear stress(τ), KN/m ²	Normal stress(σ), KN/m ²
1.	15.2	30
2.	24.56	60
3	37.96	90



Graph 1: shear stress vs normal stress

Shear strength, $\tau = 64.22 \text{ KN/m}^2$

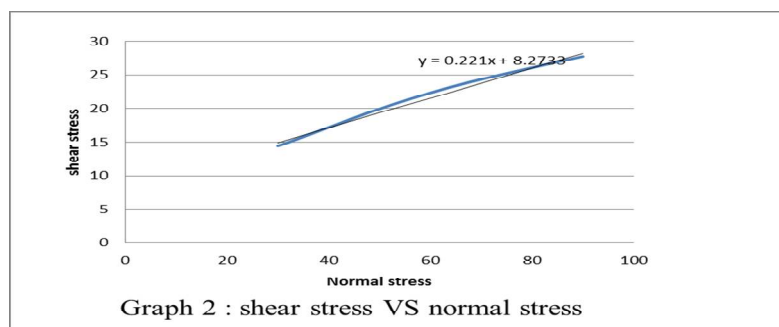
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

(ii) 80% S + 10% B + 10% RHA

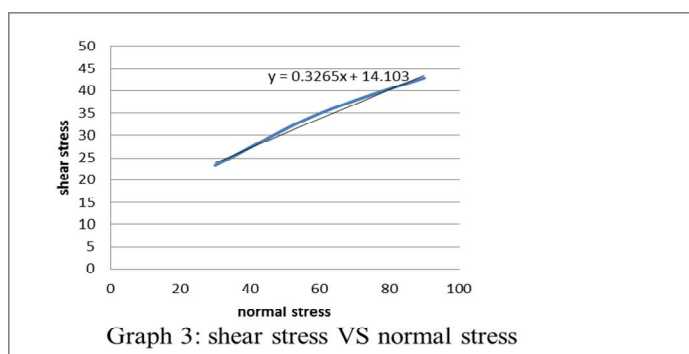
Sl. No.	Shear stress(τ), KN/m ²	Normal stress(σ), KN/m ²
1.	14.48	30
2.	22.38	60
3	27.74	90



Shear strength, $\tau = 44.91 \text{ KN/m}^2$

(iii) 70% S + 15% B + 15% RHA

Sl.No.	Shear stress(τ), KN/m ²	Normal stress(σ), KN/m ²
1.	23.30	30
2.	34.42	60
3	42.89	90



Shear strength, $\tau = 67.26 \text{ KN/m}^2$

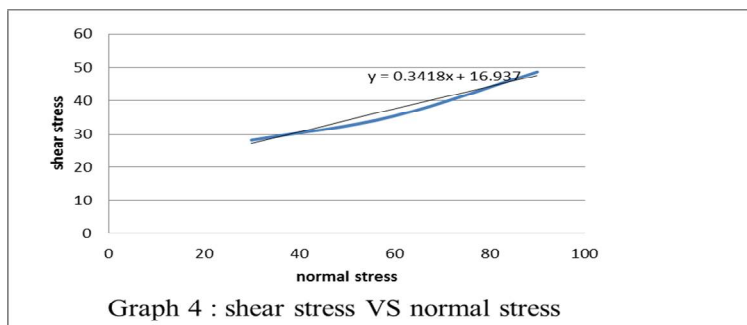
(iv) 60% Soil + 20% Bentonite + 20% RHA

Sl.No.	Shear stress(τ), KN/m ²	Normal stress(σ), KN/m ²
1.	25.32	30
2.	35.33	60
3	48.76	90

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016



Shear strength, $\tau = 79.67 \text{ KN/m}^2$

V. CONCLUSION

1. Hydraulic conductivity of the soil was high when the soil alone were tested. This shows that the soil was highly permeable. Addition of RHA and bentonite were found to reduce the permeability of soil by decreasing the amount of water passing through it. This is because the fine particle of bentonite fills the voids in the soil and thus reduce the passage of water through it. It could be concluded that addition of 20% RHA and 20% Bentonite significantly reduced the permeability of the soil. This observation can greatly help while designing Liners for landfill sites.
2. The soil sample did not possess any cohesion property. In direct shear test, the use of admixtures contribute to the improvement of the strength of the soil. RHA has the property to stabilise soil and so addition of it along with bentonite in soil improves the strength of soil. Bentonite being a clay mineral contributes to transformation in the property of soil from sandy to cohesive soil. The improvement in the strength of the soil can be observed from the Shear strength value obtained from soil sample alone and soil mixed with 20% RHA and 20% Bentonite as Shear strength, $\tau = 64.22 \text{ KN/m}^2$ (soil sample) and Shear strength, $\tau = 79.67 \text{ KN/m}^2$ (soil+20%RHA+20%B) respectively.
3. It could also be observed from the results of proctor test that OMC was increasing and dry density was decreasing as the percentage of RHA and bentonite was increased in the soil sample.
4. The soil sample being sandy soil gave zero plasticity. And it could be observed further that plastic limit was increasing and shrinkage limit was decreasing as the percentage of RHA and bentonite was increased in the soil sample.

REFERENCES

- [1] V Giridhar, P Suresh Praveen Kumar and M C Venkatasubbaiah, " Experimental studies on clay, bentonite and leachate mixer as liner material", International Journal of Innovative Research in Advanced Engineering (IJIRAE), January 2015.
- [2] N.K Ameta, D.G.M Purohit, Wayal A.S and Dangda Sandeep, "Economics of stabilizing bentonite soil with lime-gypsum", academia.edu.
- [3] Aparna Roy, "Soil stabilization using rice husk and cement", International Journal of Civil Research, ISSN 2278-3652 Vol.5, No.1,page-49-54, 2014.
- [4] Robert M. Brooks "Soil Stabilization with Fly Ash and Rice husk ash", International Journal of Research and Reviews in Applied Sciences.
- [5] B.Suneel Kumar & T.V.Preethi, "Behavior of Clayey Soil Stabilized with Rice Husk Ash & Lime", International Journal of Engineering Trends and Technology (IJETT), Volume-11 No.1, May 2014.
- [6] Dilip Shrivastava, A K Singhai and R K Yadav, "Effect of lime and rice husk ash on engineering properties of black cotton soil", International Journal of Engg. Research & Science & Technology, 2014.
- [7] Ajay kumar, Kalyani Mohanta, Devendra Kumar and Om Parkash, "Properties and Industrial Applications of Rice husk", International Journal of Emerging Technology and Advanced Engineering.
- [8] Hamzat Isah, "The effect of Rice husk ash on the chemical properties of soil", Second International Conference on Chemical, Biological and Environmental Sciences (ICCBES'2015) May 20-21, Dubai 2015.



ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

- [9] Mohammed Y. Fattah, Falah H. Rahil, and Kawther Y. H. Al-Soudany, "Improvement of Clayey Soil Characteristics Using Rice Husk Ash", Journal of Civil Engineering and Urbanism.
- [10] Agus Setyo Muntohar, "Utilization of Uncontrolled burnt Rice Husk Ash in soil improvement", Vol.4, No.2,page 100-105,ISSN 1410-9530, September 2002.
- [11] Okafor F. O. and Okonkwo U. N, "Effects of Rice Husk ash on some Geotechnical Properties of Lateritic soil," Leonardo Electronic Journal of Practices and Technologies, 8 (15), page 67-74, 2009.
- [12] //www.wikipedia.com//
- [13] Geotechnical Laboratory Manual, IIT Kanpur.