A Study on Suitability of Crusher Dust Stabilized Red Earth and Gravel as Subgrade and Sub Base Material

Prof. P.V.V.Satyanarayana[#2], Sumanjali Parimi[#1], Swathipriya.P[#3], Jahara. Sk[#4]
[#1, #3]*Asst. Prof, Department of Civil Engineering, Sathya Institute of Technology and Management – GVP, Vizianagaram, Andhra pradesh, India.*
[#2]*Professor, Department of Civil Engineering, Andhra University, Visakhapatnam, Andhra pradesh, India.*
[#4] *PG Student, Department of Civil Engineering, Andhra University, Visakhapatnam, Andhra pradesh, India.*

Abstract

India is a developing country having wide road network which require huge quantity of materials. The materials used in the pavement construction should have good quality and durability characteristics. Usually locally available material like natural soils, gravels, sands, and crushed stone can be preferred for road component material. Sometimes due to inherent poor qualities these material offers high deformations lead to failure of the pavements in various forms. In order to use locally available materials for laying of pavements, these are to be stabilized with available material, industrial wastes or additive which will improve the performance and durability which will help in lesser construction and maintenance cost.

In the present study locally available red soil and gravel soils were stabilized with the addition of crusher dust and verified their plasticity and strength characteristics. From the results obtained, the red earth can be stabilized with optimum dosage of 20% and gravel soil with 25% crusher dust. the stabilized mixes have low plasticity and high strength characteristics. These two soils satisfies their characteristics in terms of plasticity index (Ip<6) and CBR >10 for sub grade and greater than 30 for sub base in accordance with MORTH specifications.

In addition to this crusher dust stabilized, red soil and gravel as sub grade and sub base, crushed stone with crusher dust as base coarse on CBR model yields good ultimate resistance value(550 – 600 kPa) compared to their natural materials. Hence from the test results, the crusher dust stabilized Red earth and gravel can be used as pavement construction materials.

Keywords – *Red earth, Gravel, Crusher dust, Plasticity characteristics, Strength characteristics*

I. INTRODUCTION

Transportation contributes to the economic, industrial, social and cultural development of any country. The adequacy of transportation system of a country indicates its economic and social development. The pavement should be stable and non yielding, to allow the heavy wheel loads with reasonable maintenance cost, which is depends on layers of pavement such as Sub grade, Sub base and Base courses. The materials which are used as pavement materials should possess good strength and adequate plasticity characteristics. Various researches are yet to be conducted to check the suitability of locally existent soils as pavement materials.

In recent years, application of industrial wastes has been considered in the road construction. one such material is Crusher dust which is is used as a pavement material, embankment fill and construction material because of its high shear strength (Soosan et.al 2000, 2001), high CBR values (Sridharan A 2005, 2006). Collins R. J studied quarry dust in Highway Construction.

In the present study, locally available Red soil and Gravel are stabilized with optimum dosage of Crusher dust by conducting various geotechnical tests and its suitability in terms of CBR is checked by keeping Crusher dust stabilized Red earth as Sub grade and Crusher dust stabilized Gravel as Sub base material and a mix of Stone aggregate with Crusher dust as Base course material(1)

A. Objectives of Present Study

The main objective of the present study is stabilization of locally available soils like Gravel and Red soils with Crusher dust material and their mixes can be used as sub-grade and sub-base material in road construction and model studies on the pavement

materials having Red earth + Crusher dust as sub-grade, Gravel + Crusher dust as sub-base and Stone aggregate + Crusher dust as base course materials.

- To know the geotechnical Characterization of Gravel soils, Red soils, Stone aggregate.
- To know the plasticity, compaction, shear and strength characteristics of Gravel – Crusher Dust mixes, Red soils - Crusher Dust mixes, at various percentages of Crusher Dust.
- To know the Optimum percentage Crusher dust for both the mixes.
- To know the suitability of the stabilized Red soils as sub grade material, Gravel soils as Sub-base material and Stone aggregate as Base course material in accordance with MORTH specifications.

II. MATERIALS

A. *Red Soil*

Red soil is hugely available in the city of Visakhapatnam. Red soil samples are collected from three different places of Visakhapatnam at a depth of 0.5 m from ground level and their geotechnical characteristics are studied. The samples are collected from China waltair, A. U campus and Waltair uplands, Visakhapatnam. The sample collected at A. U campus shows high plasticity characteristics and less CBR value than the other two samples. Therefore the sample is stabilized with different percentage of Crusher dust and Optimum percentage is selected, stabilized material can be used as subgrade material.

B. *Gravel*

To study the suitability of Gravel as Sub base material, two gravel samples are collected from the city of Visakhapatnam and the village Venkatapuram. The samples were collected at a depth of 0.5 m from the ground level and their Geotechnical characteristics are studied. From the Test data, Visakhapatnam Gravel is suitable as sub base material as per MORTH specifications. But in Venkatapuram Gravel, the amount of fines is quite high therefore it shows high plasticity characteristics and soaked CBR values are also quite low. So, to meet the Specifications of MORTH, Venkatapuram Gravel is stabilized with optimum dosage of Crusher dust and stabilized material can be used as sub base material.

C. *Stone Aggregate*

To study the suitability of stone aggregate Crusher dust mix as a base course material, a sample of Stone aggregate is collected from the anakapalli crushing plant unit, near Visakhapatnam. The sample is mixed with a percentage of 25 % of Crusher test and its suitability is examined.

D. *Crusher Dust*

Crusher dust was collected from local crushing plant near Anakapalli, Visakhapatnam, Andhra Pradesh. The geotechnical characteristics of Crusher dust are studied.

III. METHODOLOGY

Geotechnical tests like Gradation analysis (Sieve Analysis), Consistency limits (Liquid limit, Plastic limit), IS compaction test, CBR test (Soaked), Direct shear test, Constant head permeability test are conducted on individual materials and the results of materials are tabulated below. The table is showing only the results of materials.

TABLE: 1 Various Geotechnical Characteristics of different soil samples selected at site

	Red soil collected at A.U campus	**Gravel collected at Venkatapuram village**	**Crusher dust sample**
Gradation Characteristics			
Gravel (%)	0	55	5
Sand (%)	70	31	90
Fines (%)	30	14	5
Index Properties			
Liquid limit (%)	28	36	NP
Plastic limit(%)	19	20	NP
Plasticity Index(Ip)	9	16	NP
IS classification	SC	GC	SP
Specific Gravity	2.66		2.64
Compaction Characteristics			
Optimum Moisture content	10.0	10.8	13

(OMC)(%)			
Maximum Dry Density (MDD) (g/cc)	1.98	2.06	1.9
Strength Characteristics			
California Bearing Ratio (CBR) (%) Soaked	5.0	22	8.0
Coefficient of Permeability (k) cm/sec	6.4×10^{-6}	5.5×10^{-4}	4.0×10^{-4}
Shear Parameters			
Cohesion (t/m^2)	2.0	4.0	0
Angle of internal friction (˚)	25	36	36

A. Study of Red soil – Crusher dust mixes of A.U soil sample:

From the test results it is observed that the Red soil sample collected at A.U is having good strength characteristics but possess high plasticity. To reduce plasticity and improve strength characteristics, Red soil is stabilized with different percentage of Crusher dust of 5 – 25 %, the geotechnical properties such as plasticity, compaction, strength and shear characteristics were studied. The results are tabulated in the table 2.

TABLE: 2 Geotechnical properties of Red soil – Crusher dust mixes at various % of Crusher dust

Percentage of Crusher dust	Liquid limit (L_L) (%)	Plastic limit (P_L) (%)	Plasticity index (PI) (%)	Optimm moisture content OMC(%)	Maximum dry density (MDD) (%)	Soaked CBR (%)	Cohesion(c) t/m^2	Angle of internal friction (ϕ) (deg)
0	28	19	9	10.0	1.98	5.0	2.0	26
5	26	18.5	7.5	10.2	1.99	6.0	1.6	28
10	23	18	5	10.5	2.01	8.0	1.2	30
15	NP	NP	NP	10.6	2.02	9.0	1.0	32
20	NP	NP	NP	10.7	2.02	10.0	0.5	34
25	NP	NP	NP	10.5	2.03	10.5	0	36

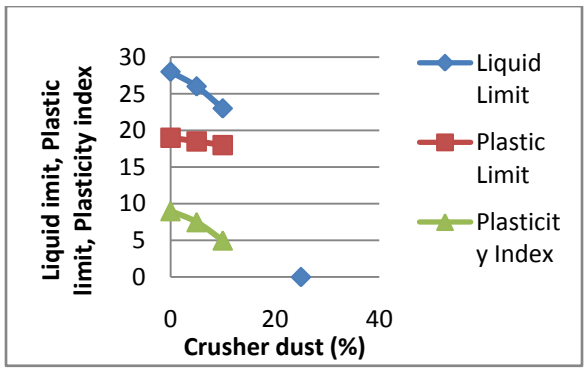

Fig. 1 Variation of Index properties of Red soil + Crusher dust (%)

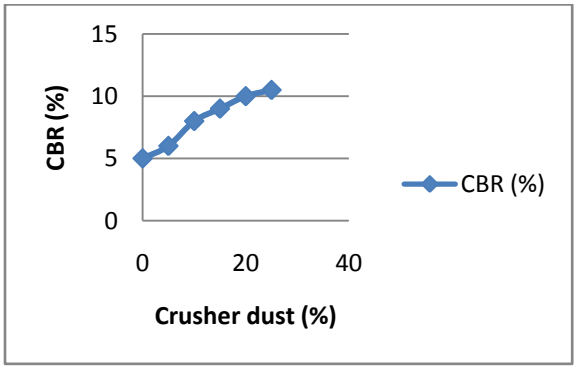

Fig. 2 Variation of CBR values of Red soil + % crusher dust.

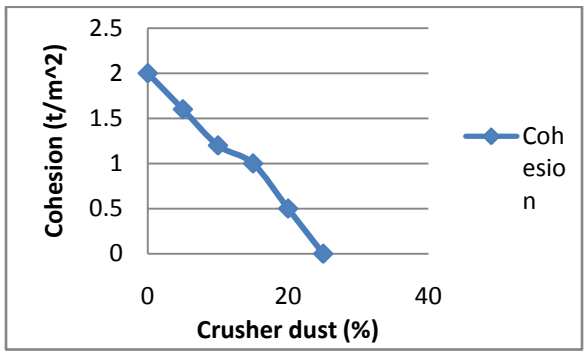

Fig. 3 Variation of Cohesion values of Red soil + Crusher dust (%)

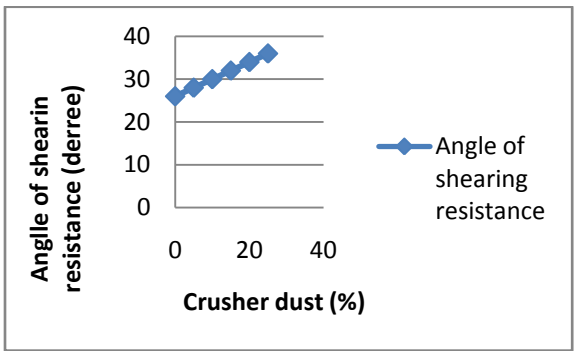

Fig. 4 Variation of angle of shearing resistance values of Red soil + Crusher dust(%)

From the test data it is observed that the addition of crusher dust to Red soil decreases liquid limit, plastic limit and plasticity index. A sharp in these values are up to the addition 10 % of crusher dust, further increase of crusher dust makes the mix non-plastic and the values of OMC and MDD are increasing with the percentage increase of Crusher dust . The increase in MDD values are due to effective interaction between crusher dust and Red soil particles make them well compacted and OMC's are increasing due to due requirement of more water needed to lubricate the particles for achieving effective compactness. As the percentage of crusher dust is increases, the CBR values of Red soil crusher dust mixes are also increases. Attainment of high values are due to more solids occupied in the given volume due to the effective interaction between the crusher dust particles, fine particles of Red soil which offer more shearing resistance against compression. The value of Cohesion (c) is decreasing and the value of Angle of shearing resistance (φ) is increasing with the increase of Crusher dust in Red soil – Crusher dust mix.

B. Study of Gravel – Crusher dust mixes of Venkatapuram soil sample:

In Venkatapuram Gravel, it is observed that a little bit of higher amount of fines than Visakhapatnam gravel. The consistency limits are higher than the Visakhapatnam gravel. The soaked CBR value is quite lower. To meet the specifications of MORTH, suitable amount of crusher dust was mixed to the Venkatapuram gravel sample and the geo-technical characteristics are studied at various percentage of crusher dust of 0 – 30 %. The results are shown in Table 3.

TABLE: 3 Geotechnical properties of Gravel – Crusher dust mixes at various % of Crusher dust

Percentage of Crusher dust	Liquid limit (L_L) (%)	Plastic limit (P_L) (%)	Plasticity index (PI) (%)	Optimm moisture content OMC(%)	Maximum dry density (MDD) (g/cc)	Soaked CBR (%)	Cohesion(c) t/m^2	Angle of internal friction (ϕ) (deg)
0	36	20	16	10.8	2.06	22	2.5	33
5	33	19.5	13.5	11	2.07	24	2.1	34
10	29	19	10	11.2	2.08	27	1.6	35
15	25	18.5	6.5	11.4	2.11	32	1	36
20	23	18	5	11.5	2.12	35	0.8	37
25	NP	NP	NP	11.6	2.11	33	0.5	38
30	NP	NP	NP	11.6	2.10	30	0	39

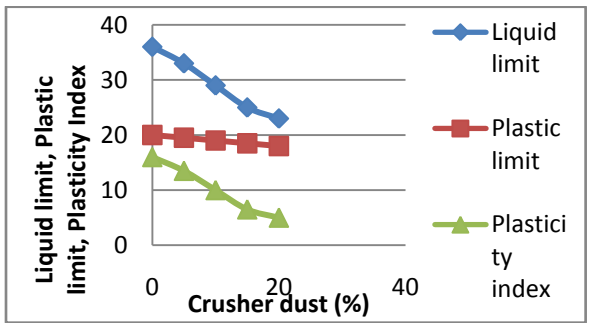

Fig. 5 Variation of Index properties for Various % of crusher dust

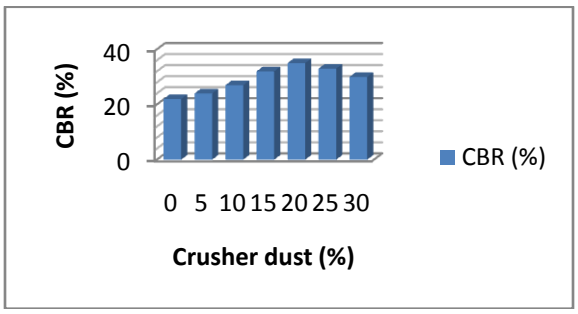

Fig. 6 Variation of CBR values for Various % of crusher dust

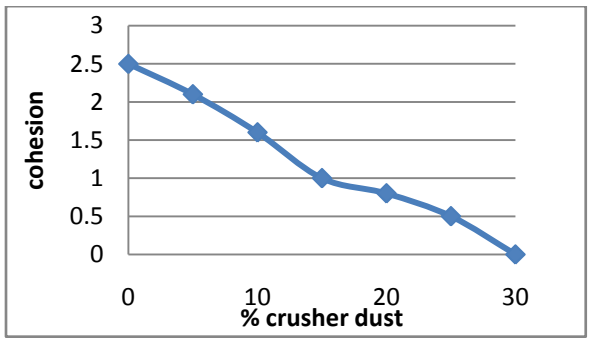

Fig. 7 Variation of Cohesion with Various % Crusher dust

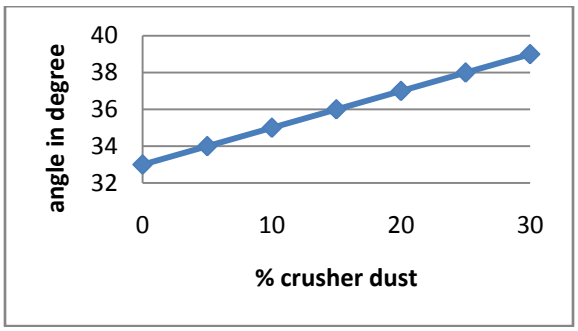

Fig. 8 Variation of Angle of shearing Resistance With various % crusher dust

From the test data it is observed that the addition of crusher dust to Gravel decreases liquid limit, plastic limit and plasticity index. A sharp in these values are up to the addition 20 % of crusher dust, further increase of crusher dust makes the mix non-plastic and the values of OMC and MDD are increasing with the percentage increase of Crusher dust. As the percentage of crusher dust is increases, the CBR values of Gravel crusher dust mixes are also increases. The value of Cohesion (c) is decreasing and the value of Angle of shearing resistance (φ) is increasing with the increase of Crusher dust in Gravel – Crusher dust mix.

C. Study of Stone aggregate – Crusher dust mix sample:

The stone aggregate is mixed with 25 of Crusher dust and its geotechnical properties such as Gradation, Compaction characteristics and Strength characteristics such as CBR are determined and the values are tabulated in table4.

TABLE: 5 OMC, MDD and CBR values of Stone aggregate – Crusher dust mix

	Value
Optimum moisture content (OMC)(%)	3.8
Maximum dry density(MDD)(g/cc)	2.24
California bearing ratio (CBR)(%)	65

D. Model preparation:

In the present investigation Red soils can be selected as sub grade material. Due to less values of CBR in soaking condition and moderate plasticity characteristics require stabilization for high traffic intensity and a CBR value of 10 has considered for sub grade. Addition of 20 % Crusher dust make Red soils low to non – plastic of CBR value 10. Similarly for Gravels as sub base material, 20 – 25 % of Crusher dust made them as non – plastic with CBR values as greater than 30. For base course material, Stone Aggregate with 25 % of Crusher dust was selected. The values of CBR for this mix are 65%.

E. C.B.R model:

Model is prepared in the CBR mould of 15.0 cm diameter and 17.5 cm height so that it has a sub grade of Red soil + 15% Crusher dust compacted at Optimum Moisture Content of thickness 7.5 cm, sub base is prepared with Gravel + 25% Crusher dust at OMC of thickness 3.75 cm and final layer is prepared with a mixture of Stone Aggregate replaced with 25% Crusher dust of 3.75 cm thickness. Top 2.5 cm left for surcharge loading.

aggregate + CRD (3.75 cm)
Gravel + CRD (3.75cm)
Red Earth + CRD (7.5 cm)

TABLE: 6 Load – Deformation values of the model prepared in CBR mould

Penetration (mm)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	10.0	15.0	18.0
Load (kg)	0	75	130	175	200	255	290	310	360	420	480	690	940	1020

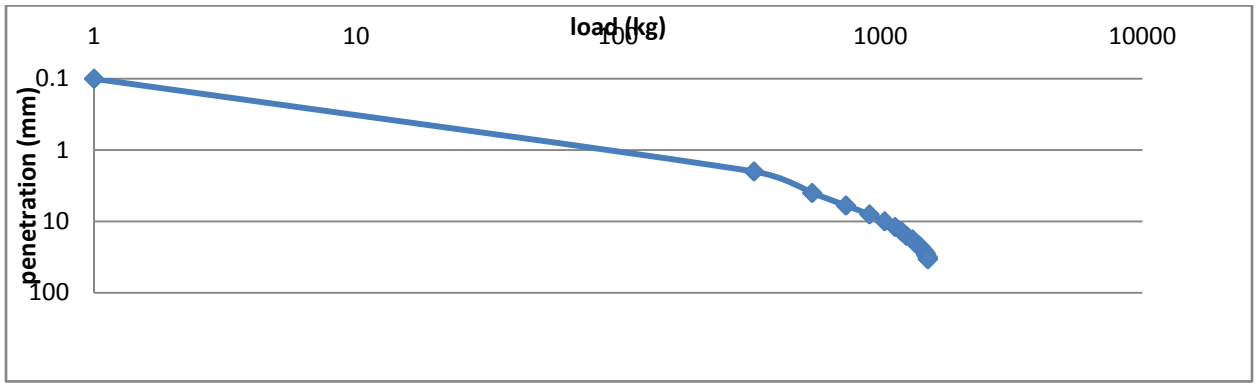

Fig. 9 CBR values of the Model – II pavement having RED EARTH + CRUSHER DUST sub-grade and GRAVEL + CRUSHER DUST as sub base and STONE AGGREGATE + CRUSHER DUST as base course.

Load at Breaking point = 1020 kg

Area = 176.71 cm^2

Stress = load / area = 5.77 kg/cm^2 = 566 kPa

From the test results and the load settlement plot of Model, it is observed that the ultimate load taken by Model is 1020 kg and ultimate stress of 566 kPa. Therefore from the model studies test, the stabilized materials performed well and can be used as pavement material.

F. Summary of Results:

In this an attempt is made to utilize the crusher dust in stabilization of gravelly soils as a sub-base material and Red soils as sub grade. From the test data it is observed that red soils lost their strengths on saturation and maintained high strength on dry condition. With the addition of 20 % of Crusher dust, the mix becomes non plastic and attains a CBR value of 10 %. Hence considering the factors like gradation, plasticity, density, shear parameters, CBR with respect to variation of moisture contents, crusher dust can effectively replace red soils as a pavement sub grade material.

In this study, Venkatapuram soil needs the stabilization with optimum dosage of crusher dust i.e, 20 %. At this percentage of, mix attained non-plastic conditions with highest CBR values of 30 %,

A model is prepared with stabilized Red soil – Crusher dust mix as sub grade, Gravel – Crusher dust as sub base and stone aggregate – crusher dust as base course. The model is loaded and an ultimate stress of 566 kPa observed at an ultimate load of 1020 kg, which meets loading requirements of pavements. Therefore, the stabilized materials can be used as pavement materials.

IV. CONCLUSIONS

From the study of the performance of Crusher Dust on pavements the following conclusions are made.

1. Crusher dust is a coarse grained material of incompressible nature and maintains high densities and high strength at their soaked conditions which can be used as sub-grade material, foundation material, fill material for the construction of roads, embankments and filling up areas.
2. Increasing the percentage of crusher dust decreases plasticity characteristics i.e, like liquid limit, plastic limit and plasticity index and increases CBR in both Gravel & Red soils.
3. Red soils require 20 % of crusher dust to make the soil non – plastic and to attain high CBR values of 10.0 % to suit as sub grade material and Gravel soils require 25 % of Crusher dust to reduce plasticity characteristics and to attain high CBR values of 30 % to suit as sub base material.
4. Model was prepared with Stabilized Red soil as sub grade and stabilized Gravel as sub base course and stone aggregate crusher dust mix as base course was tested and identified with high value of ultimate stress is in the range of 550 - 600 kPa.
5. Stabilized Red soil as Sub grade and Gravel as sub base course can be effectively used with a dosage of 20 – 25 % crusher dust can be used as road component materials.

A. Scope for Further Study:

Due to inherent qualities of crusher dust like high densities, wide variation of moisture contents, coarse grained nature, pervious nature, etc it can be used as sub-grade fill material in place of poor grounds not only red soils and also expansive soils, marshy, swampy soils and collapsible soils. In the present study Crusher Dusts was used as a stabilizer in locally available soils and these Stabilized materials were verified as Road construction material. This study can extend for the use of various stabilized materials like slag, Pond ash, Flyash, GGBS etc, as a sub-base, Base course and fill material in Road construction.

REFERENCES

[1] Sahu A.K., Sunil Kumar and Sachan A.K. 2003. Quarry Stone Waste as Fine aggregate for concrete. The Indian Concrete Journal, pp. 845-848.

[2] Satyanarayana Reddy, C.N.V and Moorthy, N.V.R (2002) "Potential of Rock Flour.

[3] Shankar, N.B and Ali, Md (1992), "Engineering Properties of Rock Flour", National Conference on Cement and Building Materials From Industrial Waste, pp. 167-172.

[4] Shrivastava V.K. and VyasNandita (2004) geological environment; Construction and maintenance of roads, workshop of MPRRDA for PMGSY 2004.

[5] Sridharan, A. and Soosan, T., G. (2005), "Utilization of Crusher Dust to Improve the Geotechnical Properties of Soils in Highway Construction", Canadian Geotechnical Journal, Vol. 28, Pp.391-400.

[6] Sridharan, A., Soosan, T.,G. and Babu, T.,J. (2006), "Shear Strength Studies on Soil-Crusher Dust Mixtures", journal of Geotechnical and Geological Engineering, Vol. 24,pp.1163-1179.

[7] Sridhran.A and Hansan Raj Singh (1988), "The Effect of Soil Parameters on Friction Coefficient in Reinforced Earth". Indian Geotechnical Journal, Vol. 18, No.4.

[8] Reddy, M.V. and Reddy, C.N.V.S., 2007, "An experimental study of rock flour and I nsulator ceramic scrap in concrete", Journal of Institute of Engineer (India), Vol 88, August, pp 47-50.