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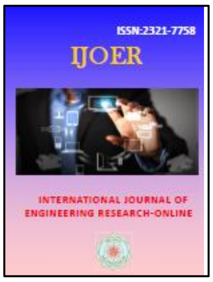
THE EXPERIMENTAL INVESTIGATION ON THE USE OF COAL MINE AS REPLACEMENT OF FINE AGGREGATES IN CONCRETE

O. VENKATESWARLU[1], M.NAGESWARARAO[2]

[1]M.Tech Structural Engineering, Loyala Institute of Technology & Management, AP

[2]Assistant Professor, Dept. of Civil Engineering, Loyala Institute of Technology & Management, AP



ABSTRACT

Waste produced during extraction and processing of various mines constitutes one of the largest waste streams in the world. It involves materials that must be removed to gain access to the mineral deposit such as topsoil, overburden waste rock, as well as tailings remaining after minerals have been extracted from the ore. The ore can be extracted using either opencast mining or underground mining. The waste generated is more during opencast mining. During opencast mining for coal, the overlying soil is removed and the fragmented waste rock is heaped in the form of overburden dumps. These occupy large amount of land, which loses its original use and generally gets soil qualities degraded. As the dump materials are generally loose, fine particles from it become highly prone to blowing by wind.

These get spread over the surrounding fertile land, flora, disturbing their natural quality and abstains the growth of fresh leaves. A positive utilization of such waste rock can not only saves considerable land and also reduces environmental problems. One of the uses can be partial replacement of fine aggregates in concrete. Concrete is one of the most used materials on the earth and it use different natural resources. Extraction of sand from rivers causes various problems. So it is important to notify different alternatives that are abundant and eco-friendly in nature. This work focus on the study of utilizing the sandstone which is overburden waste of coal mines to use in concrete as a replacement of fine aggregate. Physical properties and elemental composition of sandstone were examined in the laboratory. Physical properties of sandstone like water absorption, moisture content, fineness modulus etc., were found to be similar to conventional fine aggregate.

SEM analysis was carried out for analysing elemental composition of the sand stone. There is no sulphur content in sandstone which is a good sign to carry the replacement. Fine aggregate was replaced with sandstone at 25%, 50%, 75% and 100% compressive strength of concrete cubes was tested for 3, 7 and 28 days and split tensile and flexural strengths for 28 days. The strength was found to be increasing with increase in the sandstone content. Fine aggregate replaced by 50% sandstone gave higher strengths among all the replacements for the compressive, split tensile and flexural strengths. Fly ash is known to be one of the most important pozzolanic materials. To analyse the performance of concrete incorporated with coal mining waste and fly ash, keeping sandstone replacement as 50% and fly ash was varied by 10%, 20% and 30% as a replacement of cement and specimens were prepared. Compressive strength of concrete cubes was tested for 3, 7 and 28 days and split tensile and flexural strengths for 28 days. All the tests carried were conformed to IS standards. The concrete replaced by sandstone at 50% along with fly ash replaced by 30% for cement gave best results among all, for 28 days.

Keywords: Compatibility, Engines, Admixtures.

1. INTRODUCTION

1.1 General

Concrete is one of the basic requirements for creation of any infrastructure, buildings, roads, etc. Concrete required natural aggregates, which are obtained from a variety of resources. As sand and gravel can be extracted from rivers easily, such deposits do not require much processing other than size grading. Most of the tropical and subtropical countries still depend upon river sources. But now it is well understood that indiscriminate sand mining can cause irreparable and irreversible damages to the ecological system. So there is a need to look for alternatives such as mine waste and industrial waste. Presently there are various materials such as recycled fine most of times mine wastes are neglected as alternatives even though they are huge in quantity. In India there are two types of mining that are operated as opencast and underground mining. Open cast mining is a developmental activity, which is bound to damage the natural ecosystem by several mining activities. During opencast mining, the overlying soil is removed and the fragmented rock is heaped in the form of overburden dumps (Ghosh, 2002). Dump materials are left over the land in the form of overburden dumps. These occupy large amount of land, which loses its original use and generally gets soil qualities degraded (Barpanda et al., 2001). As the dump materials are generally loose, fine particles from it become highly prone to blowing by wind. These get spread over the surrounding fertile land, flora, disturbing their natural quality, and abstains the growth of fresh leaves.

It has been found that overburden dump top materials are usually deficient in major nutrients. Hence, most of the overburden dumps do not support plantation. A positive utilization of such waste rock can not only saves considerable land and also reduces environmental problems. One of the uses can be partial replacement of fine aggregates in concrete. At the same time, production of cement causes emission of large amount of carbondioxide (CO_2) gas into the atmosphere, a major contributor for greenhouse effect and causes global warming. Also, Portland cement being very expensive material and it acquires major cost of any construction project. There are some admixtures called pozzolonas, which are very popular to use as a replacement. For instance, Fly ash, GGBS, Rice husk ash Metakaolin etc. are used.

Fly ash is already proved as one of the best pozzolanic material and used widely. It is one of the naturally occurring products from the coal combustion process. The disposal of fly ash as dumps causes so many problems to environment. A study was done on Kulsi river, Assam and it was found that one of the causative factors for the decline of river dolphin population was discriminate sand extraction and related disturbances in the river (Mohan, 2000). Another study, was reported that sand mining in Coleroon river (tributary of Cauvery river), Tamil Nadu causes serious environmental problems in its lowland areas (Sridhar, 2004). Another report stated that illegal sand mining taking place on the banks of Shimsha river near Kokkare Bellur in Bangalore, Karnataka was affecting the life of avian fauna of that region (Ronnie, 2006). A study on East Gonja District of Ghana and Gunnarsholt area of Iceland was done and concluded that, sand mining cause loss of farm or grazing lands, enhancement of erosion and loss of vegetation, destruction of landscape, generation of conflicts, loss of biodiversity and dust pollution (Musah 2009).

1.2 Stone Powder

In one of the cases crushed stone powder was been used as a replacement of fine aggregate and ceramic scrap as partial replacement of coarse aggregate. The strengthwas increased up by 20% (Veera Reddy, 2010). In other case, stone powder has been used as a replacement of fine aggregate in Bangladesh and the compressive strength of concrete got increased by 15% higher than that of the concrete made of normal sand (Mahzuz et al., 2011). In another case where fine aggregate had partially and fully replaced by stone powder and found that concrete was effective for the replacement (Lakhan Nagpal et al., 2013).

To assess the suitability of replacement of fine aggregates with sandstone from overburden to use in concrete, laboratory scale investigations were carried out in two stages. In the first stage, studies were carried out to understand the physical and chemical composition of sandstone collected from the Singareni collieries, Srirampur Area in Adilabad

District of Telangana State. In the second stage, experiments were carried out on concrete incorporated with sandstone and fly ash.

1.3 Sample Collection

The primary objective while collecting a soil sample for laboratory analysis is that its composition should be representative of the conditions that exist in the field. The procedure involves the random collection of material in the site over the designated area and combining them to form a composite sample for analysis. The total amount of ample collected from the material is nearly 250kg. The over burden dumps shown below in Fig 1.1.

Figure 1-1(a) overburden dump

Figure 1-1 (b) overburden dump

Figure 1-1 (c) overburden dump

1.4 Materials Used

In general, concrete is a mixture of cement, fine aggregate, coarse aggregate and water. In order to utilize waste produced from different sources in concrete, sandstone was used in place of fine aggregate and fly ash from thermal power industry was used to replace cement partially. The details of the respective material used for the specimen preparation are discussed in the sections below.

Cement

Cement is a binder substance that sets and hardens and can bind other materials together. Cement used in construction can be characterized as being either hydraulic or non-hydraulic in nature, depending upon the ability of the cement to be used in the presence of water. The most important uses of cement is as a component in the production of mortar in masonry and in concrete as combination of cement and as an aggregate to form a strong building material. Ordinary Portland cement is the most common type of cement generally used around the world. Locally available 43 grade cement of ACC brand is used for experimental purpose. The physical properties of cement are given in Table 1-1.

Table 1-1: properties of cement

Properties	Experimental Results	Standards
Specific Gravity	3.11	3.10 - 3.15
Initial setting time (min)	70	30
Final setting time (min)	350	600
Fineness (%)	1.7	10(max)

Aggregates

Construction aggregate, or simply aggregate, is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag and recycled concrete. Aggregates are the most mined materials in the world. The aggregate serves as reinforcement to add strength to the overall composite material. These aggregates are mainly classified into two type's namely fine aggregate of size less than 4.75mm and coarse aggregate of size more than 4.75mm. Locally available river sand is used as fine aggregate. Gravels constitute major part of coarse aggregates.

Table 1.2 Properties of aggregates

Property	Fine Aggregate	Coarse Aggregate
Specific Gravity	2.64	2.74
Water Absorption	1.3%	0.8%
Moisture Content	Nil	Nil
Maximum Size (mm)	4.25	20

Figure 1-1 Coarse aggregates

Figure 1-2 Fine aggregates

2. LITERATURE REVIEW

In general, coal mine overburden compromises of run-of-mine waste, coarse grained washery discard, fine grained discard and slurry, rejects and tailings. Petro graphically coal mine overburden consists of argillaceous and arenaceous rocks represents mainly by mudstone, siltstone and sandstone with admixture of coal and coal shale (Twardowska et al., 2004). Surface coal mining involves material that must be removed to gain access to the coal resource including topsoil, overburden and waste rock (Zhengfu et al., 2010).

Overburden dumps change the natural land topography, affect the drainage system and prevent natural succession of plant growth (Bradshaw and Chadwick 1980) resulting in acute problems of soil erosion and environmental pollution (Singh et al., 1994;Singh et al., 1996).The environmental problems of coal mining dumps, caused by obvious factors such as development of anthropogenic landscape, land deformation and problems with establishment of vegetation (Twardowska et al., 2004). The impact of mining waste can have lasting environmental and socio-economic consequences and be extremely difficult and costly to address through remedial measures. Coal mine overburden has to be properly managed to ensure the long-term stability of disposal facilities and to prevent or minimize any water and soil pollution arising from acid or alkaline drainage and leaching of heavy metals (Zhengfu et al., 2010). Dump materials are generally loose, fine particles from it become highly prone to blowing by wind. These get spread over the surrounding fertile land, plants; disturb their natural quality, and growth of fresh leaves (Arvind Kumar et al., 2011).

3. Experimental Investigation

The experiments to find out the physical properties of sandstone and its elemental composition, strength properties of concrete incorporated with sandstone and strength properties of concrete incorporated with sandstone and fly ash together were tested as mentioned in the above sections conforming to particular Indian standard codes. The results are tabulated below in this section.

3.1 Compressive strength (IS: 516 – 1959)

Fig 3.1 : compressive strength testing machine

This test is conducted on compression testing machine. The cubes prepared for testing are 150mm x 150mm x 150mm. The cube was placed in the compression testing machine and the load on the cube is applied at a constant rate up to the failure of the specimen and the ultimate load is noted. The cube compressive strength of the concrete mix is then computed.

This test has been carried out on cube specimens at 7, 14 and 28 days age.

3.2 Split tensile strength (IS: 516 – 1959)

Splitting tensile strength is generally greater than the direct tensile strength and lower than the flexural strength (modulus of rupture). Splitting tensile strength is used in the design of structural light weight concrete members to evaluate the shear resistance provided by concrete and to determine the development length of the reinforcement.

After demoulding all the specimens they were kept in water for required no. of days in the laboratory. To test the specimens for their strength properties it was taken out form water and subjected for surface drying. Specimens were neatly cleaned with cloth, so that it doesn't contain any dust on it.

Fig 3.2: Split Tensile test on Cylinder

3.3 Grain size distribution

Grain size distribution was done by sieve analysis, with sieves ranges from 75µm to 4750µm. Wet sieve analysis was conducted totally for 5 samples to find the accurate results. For wet sieve analysis the sample was washed and passed through the sieves and dried for 24 hours. Then the weights were measured for materials retained on each sieve Based on the values obtained cumulative passed and cumulative retained were calculated for each sieve.

3.4 Workability of fresh concrete

Workability of the concrete was tested by slump cone test. For every mix Slump cone test was done and the results are listed below.

Figure 3.3 represents the mould that is kept for test process and figure 3.3 represents the flow of slump after releasing the mould. After lifting the mould, the flow was occurred. Then the height of the slump collapsed was measured and results were tabulated from the figure 3.3 it can be observed that slump is purely true.

Figure 3.3: Flow of slump after release

Figure 3.4: Slump cone test

4. RESULTS & DISCUSSION

The results of present investigation are presented both in tabulated and graphical forms. In order to facilitate the analysis, interpretation of results is carried out at each phase of experimental study. This interpretation of the results obtained based on the current knowledge available in the literature as well as on the basis of results obtained. The significance of results is assessed with reference to the standards specified by the relevant IS codes.

4.1. COMPRESSIVE STRENGTH RESULTS

Compressive strength of concrete was tested with compression testing machine in laboratory for each replacement at 3, 7 and 28 days. The arrangement of compression test is shown in Figure. Compressive strength results were given in Table 4.1.

Table 4.1: Compressive Strength results as partial replacement with sand stone

S. No.	% of Replacement of Fly Ash	Compressive Strength (N/mm^2)		
		3 Days	7 Days	28 Days
1	0	15.78	18.96	24.78
2	10	16.02	19.21	25.11
3	20	16.96	19.74	25.32
4	30	17.21	20.43	25.56
5	40	16.28	19.21	23.32

S.No.	% of Replacement of Sandstone	Compressive Strength (N/mm^2)		
		3 Days	7 Days	28 Days
1	0%	13.78	17.22	22.56
2	25%	13.89	17.24	23.33
3	50%	15.78	18.96	24.78
4	75%	15.73	18.33	24.39
5	100%	15.11	18.10	24.33

variation of compressive strength in days as % replacement of sandstone

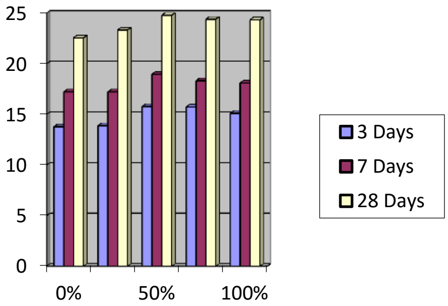


Fig. 4.1 Variation of compressive strength in days as % replacement of sandstone

Table 4.2 **compressive strength results as partial replacement of fly ash**

S. No.	% of Replacement of Fly Ash	Compressive Strength (N/mm^2)		
		3 Days	7 Days	28 Days
1	0	15.78	18.96	24.78
2	10	16.02	19.21	25.11
3	20	16.96	19.74	25.32
4	30	17.21	20.43	25.56
5	40	16.28	19.21	23.32

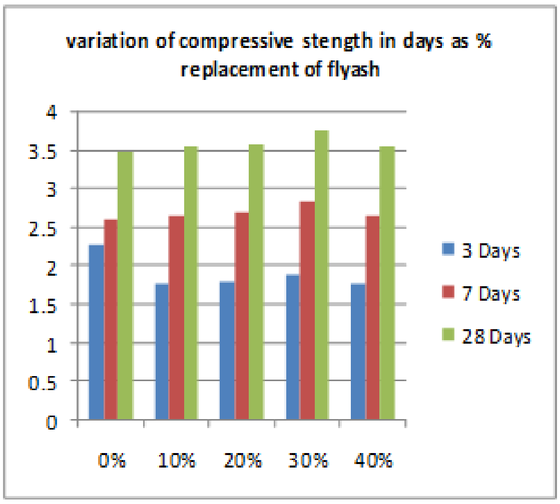


Fig 4.2: **graph showing compressive strength variation with replacement of flyash**

4.2 Split tensile strength

Split tensile strength test was conducted for cylinders. For each mix, 4 cylinders were casted and cured for 28 days. The strength and weights of the cubes are listed for each composition separately. Fig 4.3 represents the crack patterns. The results for split tensile strength were given in Table 4.3 to Table 4.4.

Table 4.3 split tensile Strength results as partial replacement with sand stone

S.No.	% of Replacement of Sandstone	Split tensile strength (N/mm^2)		
		3 days	7 days	28 days
1	0%	1.60	2.39	3.18
2	25%	2.13	2.44	3.25
3	50%	2.28	2.60	3.46
4	75%	2.25	2.57	3.42
5	100%	2.21	2.53	3.39

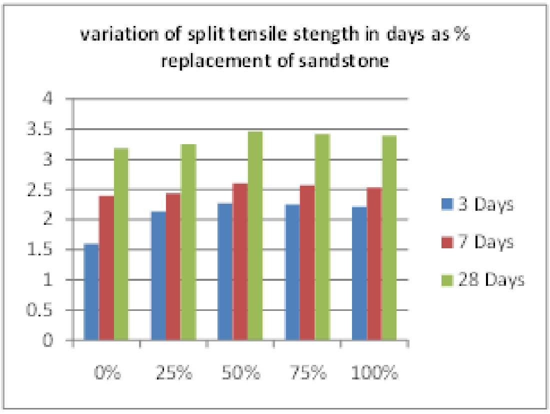


Fig 4.3 split tensile Strength results as partial replacement with sand stone.

From the above table and graph we can conclude that maximum value of split tensile strength will occur at 50 percentage of sandstone replacement with fine aggregate and the increase in strength value is around 8.8% when compared to normal concrete.

Table 4.4 split tensile Strength results as partial replacement with flyash.

S.No.	% of Replacement of Fly ash	Split tensile strength (N/mm^2)		
		3 days	7 days	28 days
1	0	2.28	2.60	3.46
2	10	2.31	2.65	3.54
3	20	2.42	2.68	3.57
4	30	2.53	2.82	3.75
5	40	2.44	2.65	3.53

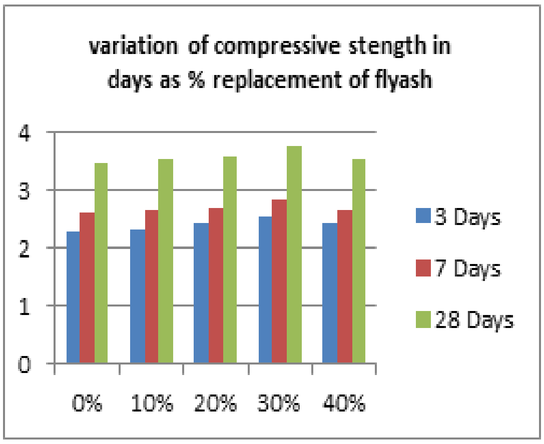


Fig 4.4 split tensile Strength results as partial replacement with fly ash.

4.3 flexural strength

Flexural strength test was conducted for prisms of500x150x150mm. For each mix, 4 cylinders were casted and cured for 28 days. The results for flexural tests are given in table 4.5 to 4.6. The distance at which crack occurred was also recorded.

From the below table and graph we can conclude that maximum value of flexural strength will occur at 50 percentage of sandstone replacement with fine aggregate and the increase in strength value is around 20 percentage when compared to normal concrete.

Table 4.5 flexural Strength results as partial replacement with sand stone

S.No.	% of Replacement of Sand stone	Flexural strength (N/mm^2)		
		3 days	7 days	28 days
1	0%	1.51	2.25	3
2	25%	1.8	2.41	3.32
3	50%	1.94	2.72	3.6
4	75%	1.92	2.62	3.52
5	100%	1.89	2.55	3.41

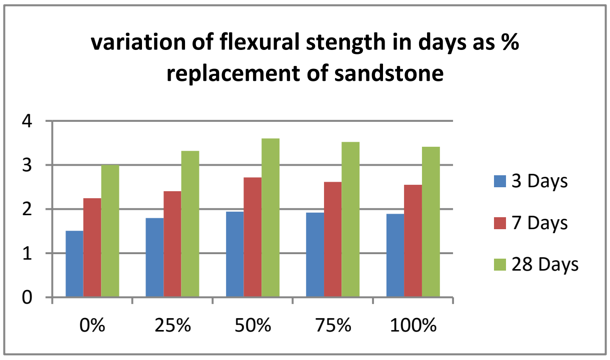


Fig. 4.5 flexural Strength results as partial replacement with sand stone

Table 4.6 flexural Strength results as partial replacement with fly ash

S.No.	% of Replacement of Fly ash	Flexural strength (N/mm^2)		
		3 days	7 days	28 days
1	0	1.94	2.72	3.60
2	10	1.97	2.75	3.62
3	20	2.08	2.78	3.70
4	30	2.16	2.89	3.80
5	40	2.10	2.72	3.62

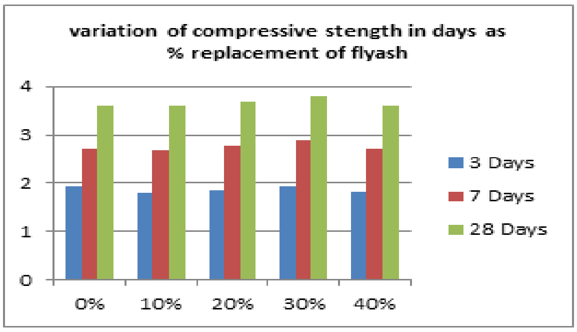


Fig. 4.6 flexural Strength results as partial replacement with fly ash

5. CONCLUSION

Based on the results obtained from the present investigation the following conclusions were made :

- The fineness modulus of the sandstone obtained as 2.25 and its clearly indicating it is a good replacement for fine aggregate.
- Specific gravity and water absorption are near to the conventional fine aggregate and doesn't show any negative impact on workability.
- Moisture content denotes that the material is feasible to transfer SEM Analysis indicates that there is presence of different oxides and high carbon content. But there are no harmful elements such as sulphur and calcium.
- Workability of the concrete increased with increasing in percentage replacement of fine aggregate. With increasing in fly ash content keeping sandstone percentage constant workability was increased. For all the cases true slump was observed. .
- Compressive strength of concrete cubes increased with the increase in percentage replacement of fine aggregate for 3, 7 and 28 days. But when fly ash was added the 28 days strength got increased by 13.3%. The maximum 28 days compressive strength was observed at fine aggregate replaced with 50% sandstone along with 30% replacement with fly ash for cement.
- Split tensile strength of concrete for was increased with increase in percentage of replacement of fine aggregate with sandstone and increased with increasing fly ash content. The maximum split tensile strength was observed at fine aggregate replaced with 50% sandstone along with 30% replacement with fly ash for cement and that percentage increase in strength was nearly 17.9.
- Flexural Strength of concrete for was increased with increase in percentage of replacement of fine aggregate with sandstone and increased with increasing fly ash content. The maximum flexural strength was observed at fine aggregate replaced with 50% sandstone along with 30% replacement with fly ash for cement and that percentage increase in strength was around 25.

REFERENCES

[1]. Anbarasan, A. and Venkatesan, M. (2015). "Effect of Robo Sand on Strength Characteristic of Recycled Aggregate Concrete." International Journal of Research in Engineering and Technology, 353-357.

[2]. Barapanda, P., Singh, S. K. and Pal, B.K. (2001). "Utilization of Coal Mining Wastes: An Overview". National Seminar on Environmental Issues and Waste Management in Mining and Allied Industries, Regional Engineering College, Rourkela, Orissa, India. 177-182.

[3]. Berryman, Charles, Jingyi Zhua, Wayne Jensena, and Maher Tadrosb. (2005). "High-percentage replacement of cement with fly ash for reinforced." Cement and Concrete Research, 1088-1091.

[4]. Bradshaw, A.D. and Chadwick, M.J. (1980). "The Restoration of Land". Blackwell Scientific Publications, Oxford, Great Britan.

[5]. Dhir, R.K, Munday, J.G.L. and Ong, L.T. (1986). "Investigation on Engineering Properties of OPC/Pulverized Fly Ash Concrete-Deformation Properties." The Structural Engineer, 64B, 2, 26-42.

[6]. Duxson-Loya, E. I., Allouche, E. N. and Vaidya, S. (2007). "Mechanical Properties of Fly Ash based Geopolymer Concrete." ACI Material Journal, 108, 300-306.

[7]. Fernandez-Jimenez, A. and Palomo, A. (2003). "Characterisation of Fly Ash: Potential Reactivity as Alkaline Cements." Fuel, 82(18), 2259-2265.

[8]. Gautam, S.P., Vikas Srivastava, and V.C. Agarwal. (2012). "Use of glass wastes as fine aggregate in Concrete." J. Acad. Indus. Res. Vol. 1(6), 320-322.

[9]. Ghosh R. (2002). "Land Use in Mining Areas of India." Envis Monograph No.9 by CME, ISSN: 0972 4656.

[10]. Gupta, Anup Kumar, and Biswajit Paul. (2015). "A Review on Utilisation of Coal Mine Overburden Dump Waste as Underground Mine Filling Material: A Sustainable Approach of Mining." Int. J. Mining and Mineral Engineering, Vol. 6, No. 2, 172-186.