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Flexural Behaviour of Reinforced Low Calcium Fly Ash based Geopolymer Concrete Beam

By S. Kumaravel & S. Thirugnanasambandam
Annamalai University, India

Abstract- The production of Ordinary Portland Cement (OPC) causes pollution to the environment, due to the emission of CO2. Geopolymer Concrete,an alternate materialis introduced to replace OPC. Low Calcium Fly ash, a by-product from the coal industry, is widely available in the world. Silicate and Alumina are rich inFly ash.Hence it reacts with alkaline solution to produce Alumina silicate gel that binds the aggregate to produce a good concrete. The compressive strength increases with the increasing of fly ash fineness and thus the reduction in porosity can be obtained. The flexural behavior of Geopolymer concrete (GPC) beams and control cement concrete beams are examined. The designed compressive strength of concrete is 50N/mm2. A total of four beams is castover an effective span of 3000 mm and tested up to failure under static loads. The load-displacement response of the geopolymer concrete beams and control beams are obtained and compared with the theoretical results. The results show that thegeopolymer concrete beams exhibit increased flexural strength.The deflections at different stages including service load and peak load stage are higher for GPC beams.

Keywords: flexural behaviour, reinforced concrete, geopolymer concrete, beams.

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FLEXURALBEHAVIOUROFREINFORCEDLOWCALCIUMFLYASHBASEDGEOPOLYMERCONCRETEBEAM

Strictly as per the compliance and regulations of :

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S. Kumaravel [α] & S. Thirugnanasambandam [σ]

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Keywords: flexural behaviour, reinforced concrete, geopolymer concrete, beams.

I. Introduction

Concrete is widely used as one of the important construction material. Portland cement is the main component of making concrete. The Cement Industries are responsible for the emissionsCO_2. The production of one ton Portland cement produces approximately one ton of CO_2 to the atmosphere[1]. Many efforts are being made in order to reduce the use of Portland cement in Concrete. In order to finding an alternative cementing materials such as fly ash, silica fume, ground granulated blast furnace slag, rise husk ash etc. The proposed an alkaline liquid that could be used to react with the Silicon (Si) and Aluminium (Al) to produce binders. Because of the chemical reaction that takes place in the polymerization process, Davidovits coined the term "Geopolymer" to represent these binders[2]. The Geopolymer technology shows considerable promise for application in concrete industry as an alternative binder to the Portland cement[3].

II. Geopolymer Concrete

The main constituents of geopolymersare the source materials and the alkaline liquids. The source materials for geopolymers based alumino-silicate should be rich in Silicon and Aluminium. Silicon and Aluminium are found in natural minerals such as kaolinite, clays, micas, and alousite, spinel, etc[4]. And also alternatively found in by-product materials such as fly ash, silica fume, slag, rice husk ash, red mud, etc. The alkaline liquids are formed from soluble alkali metals that are usually sodium or potassium based. The combination of sodium hydroxide with sodium silicate is known as alkaline liquids. The liquidsratios are 2.5.

III. Experimetal Programe

a) Materials

Low-calcium (ASTM Class F) fly ash obtained from Mettur Thermal Power Station, Tamilnadu is used in this research[5]. Acoarse and fine aggregates used by the concrete industry are suitable to manufacture geopolymer concrete. The aggregate grading curves currently used in concrete practice are applicable in the case of geopolymer concrete[6].The properties of aggregate used Specific gravity of fine and coarse aggregate -2.66 and2.70, Fineness modulus of fine and coarse aggregate - 2.43 and 6.71.

b) Alkaline Liquid

It is recommended that the alkaline liquid is prepared by mixing sodium silicate and sodium hydroxide solutions allowing the mix for a minimum period of 24 hours to the reaction of polymerization. The sodium silicate solution is commercially available in different grades. The sodium silicate solution (Na_2SiO_3) withSodium Hydroxide (NaOH) ratio by mass of 2.5 is used. The sodium hydroxide with 97-98% purity in pellet form is commercially available. The solids are dissolved in water to make a solution with the required concentration. The 14 Molar (14 M) solutionsare used[7]. Since the molecular weight of Sodium Hydroxide is 40, the mass of NaOH solids in a solution varies depending on the concentration of the solution. The materials required for making geopolymer concrete is shown in figure 1. The M 50 grade 1:1.25:2.45 is tried in this research[8]. The same ratio of mix is tried in the geopolymer concrete also. The constituents of geopolymer concrete of 14 Molarity Sodium Hydroxide for M50 grade concrete (1:1.25:2.45) is shown in Table 1.

c) Mixing, Casting and Curing

The geopolymer concrete is manufactured by adopting the conventional techniques used in the

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manufacture of Portland cement concrete. The fly ash and the fine aggregate which are dry mixed together in 50-litre capacity Pan Mixer for three minutes. The saturated surface dry (SSD) coarse aggregate is mixed with the fly ash and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch. The alkaline solution with'naphthalene sulphonate' super plaster is added and the entire batch mix for four minutes[9]. The fresh concrete is cast and compacted by the usual methods used in the case of Portland cement concrete. The workability of fresh concrete is measured by means of the conventional slump test. The slump measured is 110mm shown in figure 2. The prepared concrete is kept in moulds of specimen cubes, cylinder, prisms and beams shown in figure 3.

Table 1 : Constituents of Geopolymer Concrete

DESCRIPTION	QUANTITY
FLYASH	510 kg / m^3
Na_2SiO_3 / NaOH	2.5
(Na_2SiO_3 + NaOH) / FLYASH	0.45
NaOHsolid	36.80 kg / m^3
WATER (added with NaOHsolid)	28.91 kg / m^3
Na_2SiO_3 Solution	164.30 kg / m^3
Fineaggregate	637.50 kg / m^3
Coarseaggregate(<10mm)	1249.50 kg / m^3
Super plaster	4 Lit./ m^3
24 Hours Curing (Hot air)	75° C

Figure 1 : Materials for Geopolymer Concrete

Figure 2: Slump Test

After casting the specimens, they are kept in rest period in room temperature for one day. The term 'Rest Period' is coined to indicate the time taken from completion of casting of test specimen to the start ofcuring at an elevated temperature[10]. The geopolymer concrete specimens areplaced in an autoclave for 24 hours, hotcuring at a temperature of 75°C before it is de-moulded (figure 4). The compressive strength of geopolymer concrete cubes is increaseswith the increase in age. The densityofgeopolymer concrete is around 2350 kg/m^3.

Figure 3 : Casting of Specimens

Figure4 : Specimens in Curred Beam

IV. Experimental Investigation

The test program consists of casting and testing fourbeamsingiven size 125 X 250 X 3200 mmout of which two are control cement concrete beams and other two are geopolymer concrete beams.The beams designed as under reinforced section[11]. It is reinforced with 2-16 # and 1-12 # at bottom, 2–12 # at top using 6mm diameter stirrups @ 150 mm c/c. The control cement concrete beams cast using M50 grade (1:1.25:2.45) with water cement ratio of 0.32and Fe415 grade steel[12, 13]. Ordinary Portland cement, natural river sand and the crushed granite of maximum size 12.5 mm are used for control concrete. High yield strength deformed (HYSD) bars of 16 and 12 mm diameter with mean strength of 485 N/mm^2 is used.The elastic modulus of the concrete is found as 2.53×10^4N/$mm^2$and the Poisson ratio found on 0.14.The control beams and geopolymer concrete beams are designated as RCC-I, RCC-II and GPC-I, GPC-II respectively. The companion cubes 100 x100 x100mm size and cylinders 100mm diameter x 200mm height are also cast along with the beams and tested.

V. Test Setup

The test setup for flexural test is shown in figure5. The test specimen is mounted in abeam testing frame of 200kN capacity. The beams are simply supported over a span of 3000mm, and subjected to two concentrated loads placed symmetrically on the span. The distance between the loads is 1000mm.The load is applied on two points each 500mm away from the centre of the beam towards the support. Dial gauges of 0.001mm least count is used for measuring the deflections under the load points and at mid span for measuring the deflection. The dial gauge readings are recorded atdifferent loads. The strain in concrete is measured using a Demecgauge. An automatic data acquisition unit is used to collect the data during test. LinearVariabledata Transformers (LVDTs) is placed atmid span and under the load points of beam. The load is appliedat intervals of 2.5 kN. The first crack loads are obtained by visual examination. The crack patterns of the geopolymer concrete beam (GPC-I) is shown in figure 6.

Figure 5 : Test Setup

Figure 6 : Crack Pattern GPC-I Beam

Table 2 : Summary of Test Results

Sl. No.	Beam Code	Ist Crack Load (kN)	Service Load (kN)	Yield Load (kN)	Ultimate load(kN)		Max. Deflection (mm)	
					Experimental	Numerical (ANSYS)	Experimental	Numerical (ANSYS)
1	RCC – I	20.00	64.67	95.00	97.00	96.00	55.00	53.00
2	RCC – II	17.50	62.34	92.50	93.50	96.00	52.00	53.00
3	GPC – I	20.00	68.34	100.00	102.50	100.00	60.00	55.00
4	GPC – II	20.00	65.00	97.50	98.50	100.00	57.00	55.00

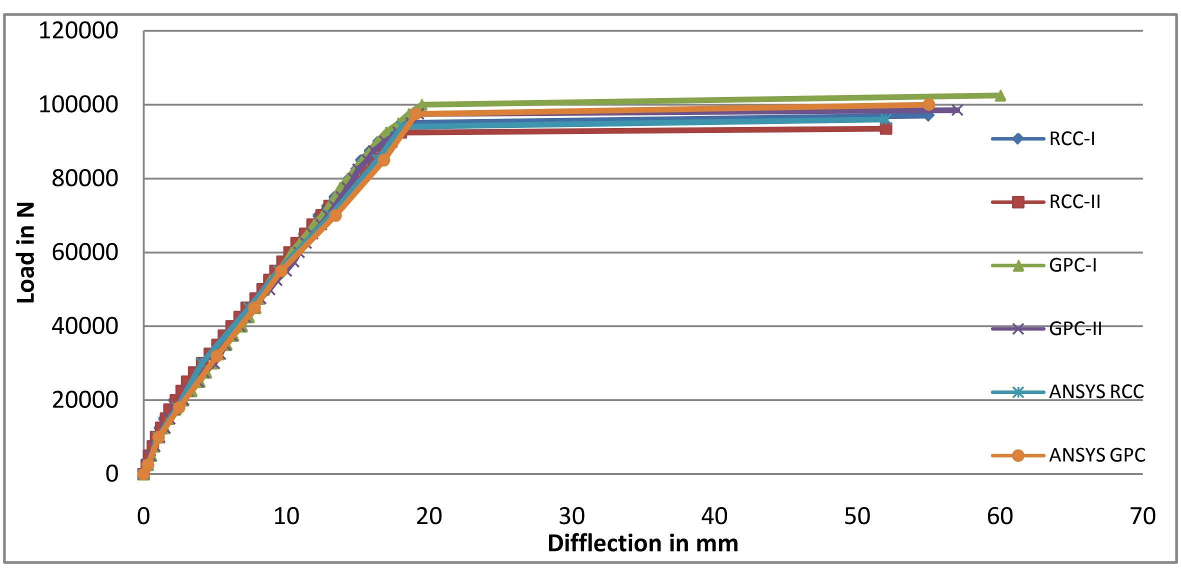

Figure 7 : Load - Deflection Relationships for RCC and GPC Beam

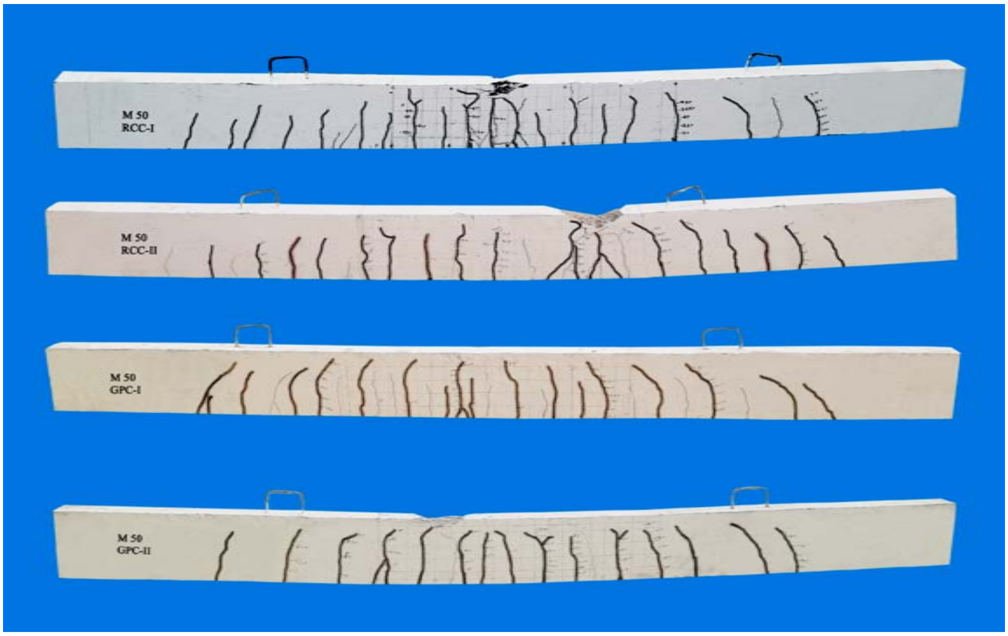

Figure 8 : Crack pattern of RCC and GPC beams

VI. Numerical Calculation

Use of FEA software ANSYS is adopted for predicting the loaddisplacementresponse from the control beams and geopolymer concrete beams-numerically. The mesh model defined 733 nodes and 700 elements. The programme offers solid65 for beam element (figure 9), and link8 for steel element (figure 10). The generated model for beamsare RCC-I, RCC-II and GPC-I,GPC-II. A typical deflected shapeat ultimate stage of GPC-I is shown infigure 11. The experimental and numerical (ANSYS) loaddeflectioncurves are compared for both control beam RCC-I, RCC-II and GPC-I, GPC-II are shown in figure 8. It can be seen that the predicted deflections are in closeagreement with the experimental results[14]. Comparisons ofultimate loads for experimental and numerical (ANSYS) results are shown in Table 2.

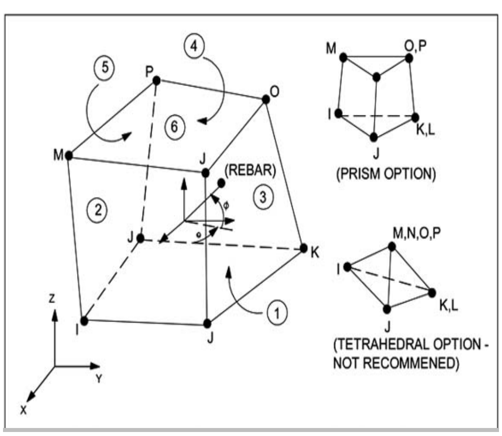

Figure 9 : Solid65 Geometry

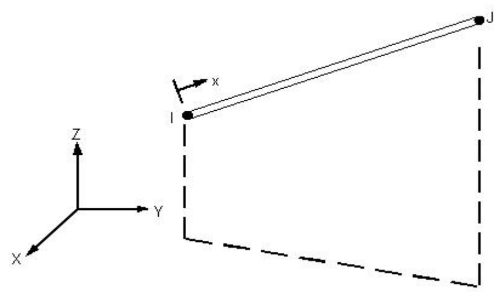

Figure 10 : Link 8 Geometry

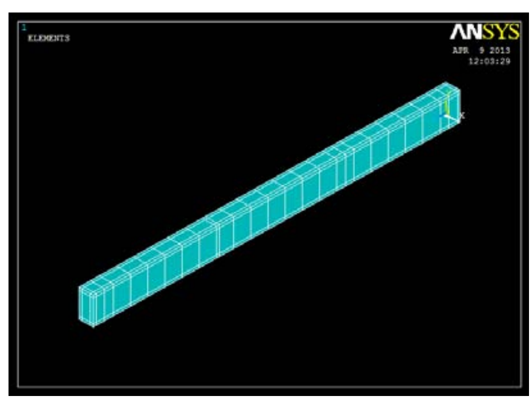

Figure 11 : Mesh Modelling

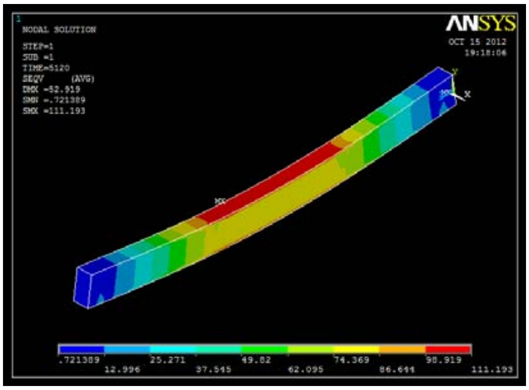

Figure 12 : A Typical Deflected Shapes

VII. Results And Disscussions

The average compressive strength of cement concrete cubes and geopolymer cubes are obtained as 57.5 N/mm^{2}and 59.0 N/mm^{2}respectively. The test results of strength, deformation properties of control beams and geopolymer beams are reported in Table 2. The load-deflection relationship is obtained using deflection measurements from LVDTs and strain data collected from Demec gauges for control beams and geopolymer concrete beams under static monotonic loading are presented. From the load deflection it is clear that the geopolymer beams exhibit similar behaviour with respect to the control beams, and crack pattern of all the beams are shown in figure 8.

VIII. Conclusions

The research investigations carried out on the reinforced geopolymer concrete beams and conventional Portland cement concrete beams areto be concluded that:

a) The compressive strength of cement concrete and geopolymer concrete cubes are obtained as57.5 N/mm^{2}and 59.0 N/mm^2. The slump of geopolymer concrete is obtained as 110 mm even without any addition of water.
b) The load deflection characteristics obtained for the cement concretebeams and geopolymer concrete beams are almost similar curvature. The first cracking load of geopolymer concrete beams shows slightly higher when compared to cement concrete beams.
c) The average service load of geopolymer concrete beams shows 7.9% higher than the cement concrete beams.
d) The average ultimate load carrying capacity of geopolymer concrete beams shows 5.68% higher than cement concrete beams.
e) The crack patterns and failure modes observed for geopolymer concrete beams are found to be similar to the cement concrete beams. The beams failed initially by yielding of the tensile steel followed by the crushing of concrete in the compression face.

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Deep Foundations in Formations with Thick Layers of Intermediate Geomaterials and Deep Stable Strata

By Medubi, A. & Bankole, G.M.
Kaduna Polytechnic, Nigeria

Abstract- This work entails the foundation studies, analysis and design that was conducted for a proposed development in the central area of the federal capital of Nigeria. The work encompasses extensive field work, experimental regime, laboratory testing and analyses of the deduced data. The work entails boring of twenty (20 Nos.) rotary drillings with rock coring as well as fifty (50 Nos.) mechanised percussion drilling with standard penetration tests (SPT). The latter gave refusal at between 8.15 and 9.65m while the rotary drilling depths were between 21 – 40m. These revealed sandy silt, silty sand, laterite, lateritic clay and concretionary laterite as the overburden material. Weathered and fresh basement rock were proved between 15 and 40m. Geophysical survey, by the use of vertical electrical sounding predicted weathered and fresh basement rock at varying depth of 18 -50m. The bearing capacity of the overburden material range from 28 – 400kN/m2 (Factor of safety of 2.5) and >1000kN/m2 for fresh basement rock. 600mm and 900mm ϕ bored and cased piles were recommended as foundation for the facility up to depth of 50m below the ground level. This is to take care of the depth to the stable strata resulting from the thickness of the intermediate geomaterial.

Keywords: foundations, bearing capacity, intermediate geomaterial, fresh rock, piles, stable strata.

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DEEPFOUNDATIONSINFORMATIONSWITHTHICKLAYERSOFINTERMEDIATEGEOMATERIALSANDDEEPSTABLESTRATA

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Deep Foundations in Formations with Thick Layers of Intermediate Geomaterials and Deep Stable Strata

Medubi, A. [α] & Bankole, G.M. [σ]

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I. Introduction

Deep foundation, that necessitates the use of piles to carry loads from heavy superstructure to stable underlying structure are preceded by an extensive region of foundation investigation. This is done to characterize the underlying soil and rock formation and their attendant engineering parameter vis-à-vis their ability to offer adequate support to the facility. Expectedly, characterization of the underlying soils would be done taking cognizance of the expected load from superstructure and all external loading elements.

This work is premised on the investigation carried out for an extensive building development that includes a 150m tower, in the central area of Abuja, the Federal Capital Territory of Nigeria in the North central geopolitical zone. The work entails field investigations, laboratory test analysis, foundation analysis and design.

The underlying characteristics of the area, that elicit special interest, is the occurrence of a thick layer of intermediate geomaterials, ranging from 18 – 40m in some of the deep borings carried out for the studies. This was also shown by geophysical survey carried out which revealed deep layers of weathered/fractured rock. The depth to firm strata, indicated by fresh basement rock was up to 50m at some of the locations.

- Location, Description and Geomorphology of the Area

The location for the study, from which the data for this studies are deduced, is in Abuja, the Federal Capital of Nigeria within the north central region of Nigeria. This is located within longitude 70 and 80E and latitude 8030' and 9030' N.

The area is in a typical basement complex formation and comprises of granite rock of the gneiss migmatite complex which are granite rocks of the Precambrian era.

The data were obtained as output from the extensive geotechnical investigations for a facility that comprises of a cocktail of different buildings. This includes a 150m tower.

The area is in a built up area with relatively level terrain and sparse vegetation.

a) Stratigraphy

The formation that underlies this area is predominantly lateritic soils which were proved between 15 – 36m. These are underlain by thick layers of intermediate geomaterial (weathered rock) which were further underlain by fresh basement/fractured rock. These were observed from 15 – 50m.

II. Research Methodology

The work entailed field investigation as well as laboratory test and analysis. These data formed basic inputs into the analysis design of foundations for infrastructural developments. These are to precede the construction of this facility.

a) Field Investigation

The field work was facilitated by a combination of geophysical and geotechnical investigation to characterize the underlying strata.

A geophysical investigation was done with the use of a terameter to measure the resistivity of the ground and delineate the lithology as a function of their respective resistivities. ABEM Terrameter SAS 300c was used to conduct resistivity surveys. These were done at

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designated vertical electrical sounding (VES) points chosen to coincide with points where geotechnical borings were conducted. Geotechnical investigations entailed carrying out a total of fifty seven (57 Nos) mechanized percussion drilling with standard penetration test (SPT) and rotary drilling with rock coring at twenty seven (27) points. These tests were in accordance with BS 1377 (1990) and ASTM D 420, D 1586-08a, D 1587 – 08 and D 2113 – 08(2009); further guides were provided by Kulhawy and Mayne (1990) as well as Mitchel (1978). Mayne (2001) and Meyerhof (1956) have highlighted the use of various penetration testing techniques (including SPT) for site characterization.

The prescribed U-tube (Acker, 1974 and ASTM D 1587 – 08, 2009) was used to recover undisturbed samples while the split barrel sampler as presented by BS 1377 (1990) and ASTM D 1586 – 08a (2009) was used for disturbed spoon samples. The results of the standard penetration test (SPT) N-values are shown in Table 1 and the plot are shown in figure 1.

Table 1 : N-values from penetration test

Depth (m)	N - values
0 -0.6	16 - 100
1.5 – 2.1	7 - 100
3.0 – 3.6	20 – 100
4.5 – 5.1	35 – 100
6.0 – 6.6	52 - 100
7.5 – 8.1	58 - 100
9 – 9.6	>100

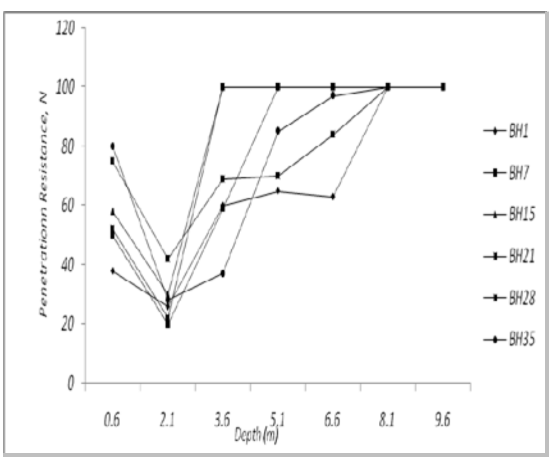

Figure 1 : Plot of Penetration Resistance (N-value) against Depth

- Laboratory Testing

The tests conducted for this work include:

a) Particle size distribution (PSD) test;
b) Atterberg's limits test;
c) Direct shear tests;
d) Consolidation/oedometer test.

All of these tests were done in accordance with specification laid out in BS 1377 (1990) and ASTM D 2850 – 03a(2007), D 2435 – 04, D 3080 – 04,D 1486 – 04, D 4767 – 06, D 6528 – 07 and D 2487 – 06e1 (2009).

III. Results and Discussion

Table 2 show a summary of the results of laboratory tests on recovered disturbed and undisturbed samples.

The index property tests reveals a proportion of fines, as shown by the percentage passing the #200 test sieve to be between 2 and 63.2% and liquid limit (LL) ranging between 19.7 and 45 % as well as plasticity index (PI) of between 1.3 and 25.4 %. The strength properties of the soils gives cohesion ranging from 0 – 47 kN/m2 and friction angle ranging from 14 -430. There properties are plotted in figures 2 – 5.

Table 2 : Geotechnical properties of recovered samples from test borings

Property	Range of test values
Natural moisture content, NMC (%)	3 - 38
Liquid limit, LL (%)	19.7 – 45
Plastic limit, PL (%)	9 - 30
Plasticity index, PI (%)	1.3 – 25.4
Percentage passing No. 200 test sieve	2 – 63.2
Specific gravity	2.3 – 2.81
Unit weight (kN/m^3)	16.28 – 83
Angle of internal friction (^{0})	14 - 43
Cohesion (kN/m^2)	0 - 47

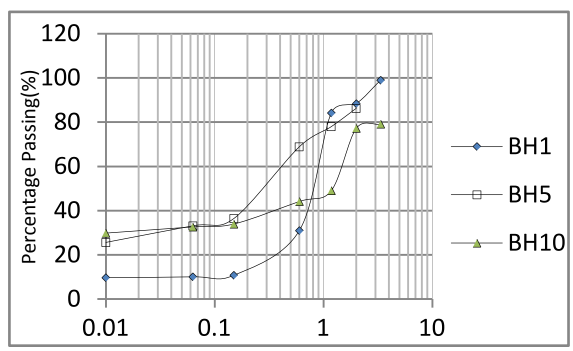

Figure 2 : Particle size distribution curve (PSD) for selected samples

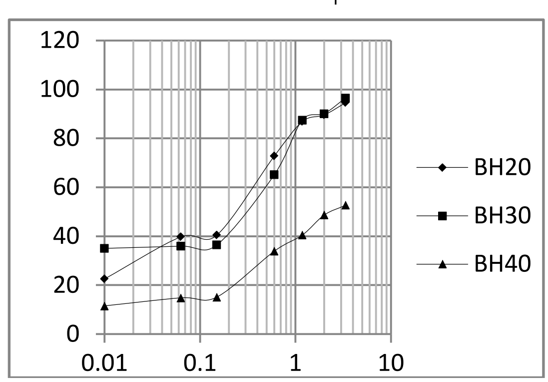

Figure 3 : Particle size distribution curve (PSD) for selected samples

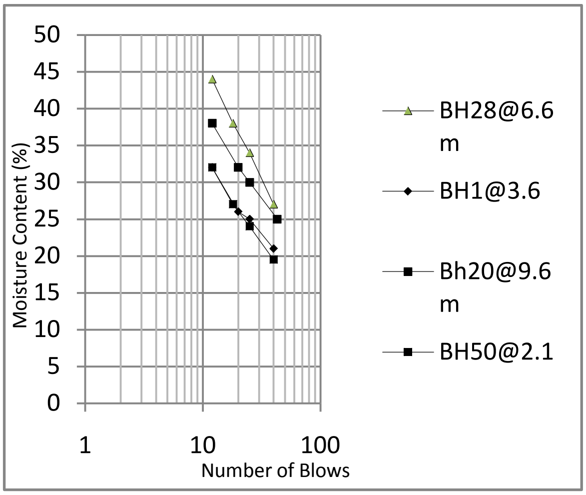

Figure 4 : Plot of liquid limit test result for recovered cohesive samples

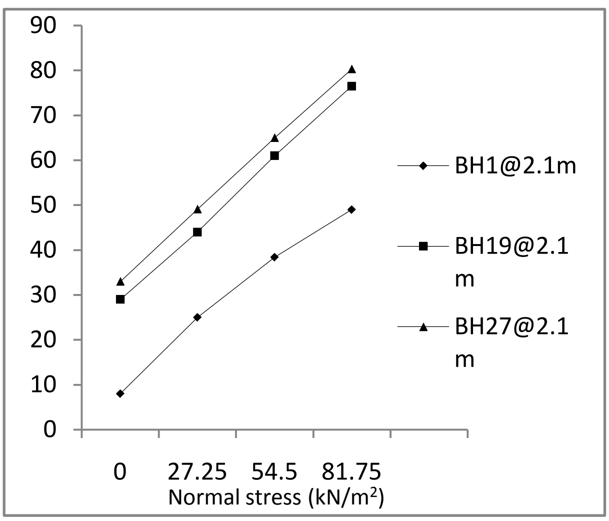

Figure 5 : Plot of shear strength properties for selected recovered samples

a) Stratification of the Lithologies

The stratigraphy of the location is as deduced from geophysical survey, percussion drilling and rotary drilling with rock coring. This is specifically with the purpose of delineating the various lithologies in the location. For this location, the stratigraphy comprises of a dense layer of laterite and lateritic clays up to 18m. These are further underlain by a dense layer of weathered/fracture basement rock with the fresh dense granite rock up to depth of 28.5-50.0m.

Oliver (1996), Kinnicut et al (1996) and Smith (1989) used various techniques to model ground conditions for development of stratigraphies.

The various stratigraphies are shown in table 3 and in the plot of the geophysical survey result shown in figure 6.

Table 3 : Lithology from percussion and rotary drilling

Depth (m)	Description of soil and rock formation
0 – 3	Silty sand, sandy silt, sandy clay, clayey sand, clayey silt, laterite, lateritic clay and concretionary laterite
3 – 6	Laterite, lateritic clay and concretionary laterite
6 – 9	Laterite, lateritic clay and concretionary laterite
9 – 12	Laterite, lateritic clay and sand
12 – 15	Sand, clayey sand, silty clay and lateritic clay
15 – 18	Sand and silty clay
18 – 21	Sand and highly weathered rock
21 – 24	Sand, sandy clay and weathered rock
24 – 27	Sand, sandy clay, clayey sand and weathered rock
27 – 30	Sand, weathered rock and fresh rock
30 – 33	Sand, weathered rock and fresh rock
33 – 36	Sand, weathered rock and fresh rock
36 -39	Weathered rock and fresh rock

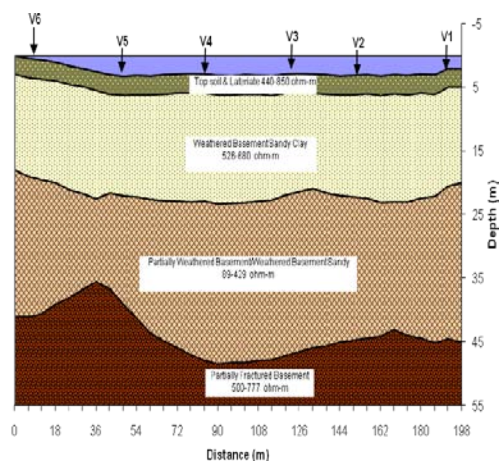

Figure 6 : Geoelectric section obtained from resistivity survey

b) Foundation Analysis and Recommended Design

Preliminary ground characterization by percussion drilling with penetration testing shows overburden depth of between 0 and 33m comprising predominantly of laterites and latentic clays with bearing pressures of between 70 and 1000 kN/m^2. The layers of weathered/fractured basement between 18 – 39m have bearing capacities of >1000kN/m^2. Fresh basement rock lies between 28.5-50m. However, fresh rock was encountered at 28.5m only in one of the borings, while most of the basement formation was observed near 50m depth.

The combined factors of the type of facilities to be constructed at this development (which include a 150m high tower) and the characteristics of the underlying foundation necessitates the use of deep foundation. This specifically entails the use of long piles

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to transmit the load from the superstructure to the depth of fresh basement rock strata.

The capacity of the piles was deduced using the soil parameters derived from the characterization and testing to analyse the soil-pile interaction. The capacity of the piles were deduced as a combination of end bearing and frictional resistance. Shoda (2007) Sahadja (2011), Medubi et al (2012) and Mason (2012) have all analysed various techniques of pile capacity evaluation in various lithologies and for various types of facilities. The Meyerhof's method was used for this work.

The capacities of piles deduced for this work are shown in Table4.

Table 4 : Pile capacity results for 900mm ϕ

Boring No.	Pile Diameter (m)	Pile length (m)	End Resistance (kN/m^2)	Friction Resistance (kN/m^2)	Total pile capacity (kN)	Safe Pile Capacity,kN (FOS=2.5)
BH1	0.900	50.0	1825.179	1291.4	3116.579	1247
BH2	0.900	50.0	2445.067	1730	4175.067	1670
BH3	0.900	50.0	2295.253	1624	3919.253	1568
BH6	0.900	50.0	1913.936	1354.2	3268.136	1307
BH7	0.900	50.0	2136.112	1511.4	3647.512	1459
BH8	0.900	50.0	1405.136	994.2	2399.336	960
BH9	0.900	50.0	1772.603	1254.2	3026.803	1211
BH10	0.900	50.0	1833.376	1297.2	3130.576	1252
BH40	0.900	50.0	1599.045	1131.4	2730.445	1092
BH41	0.900	50.0	1700.24	1203	2903.24	1161
BH42	0.900	50.0	1990.821	1408.6	3399.421	1360
BH45	0.900	50.0	1837.333	1300	3137.333	1255
BH46	0.900	50.0	2128.197	1505.8	3633.997	1454
BH49	0.900	50.0	2285.643	1617.2	3902.843	1561
BH50	0.900	50.0	2483.509	1757.2	4240.709	1696

IV. Conclusion

The work entailed a detailed study of ground condition, analysis of derived parameters with respect to foundation design and evaluation of foundation type appropriate for the stated condition. The investigations of the ground condition were facilitated by the use of geotechnical and geophysical studies to characterize the area.

The materials encountered were predominantly laterites with bearing pressures ranging from 70 – 1000kN/m^2. Weathered/fractured basement underlay the overburdens layers at between 15 – 50m with bearing pressures of >1000kN/m2. Fresh basement granites rock were observed between 18.5-50m Deep foundation, specifically end bearing piles were deduced as the appropriate means of transferring the structural loads to the underlying formation. The piles have pile capacity of between 960 – 1931 kN as deduced from the soil parameters obtained from all the relevant test.

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Integrated Approach to Investigation of Effect of Salt on Bitumen Properties and Stability of Flexible Pavement in Coastal Areas

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Abstract- Demand for modifications is increasing throughout the world parallel to develop the existing highway materials to fulfill the increasing demand of vehicles. Some materials produce good effect and enhance the strength as well as qualities of bitumen. On the other hand, some materials are responsible for adverse effect on the bitumen. In saline areas like coastal regions, the salt plays a significant role on the bituminous pavement. In this area, the most of the highways come to contact with salts content materials. In present study, the focus was given to find the various effects of salts on bitumen and bituminous mixers. A number of samples were prepared with addition of sodium chloride with respect to 2%, 4%, 6%, 8%, and 10% weight of bitumen. To determine its behavior and suitability, a variety of tests such as penetration test, softening point test, flash point and fire point test, ductility test, specific gravity test, solubility test etc. were conducted by standard ASTM method. It was observed from laboratory test that the penetration and specific gravity value are gradually increased and ductility, flash point, fire point, and softening point was gradually decreased due to the increase of salts content in a bituminous mix. To observe the effect of salt on stability of flexible pavement Marshall Mix design method was used with varying percentage of salt content. The stability value of bituminous mixes was decreased with increase the salt content in bitumen.

Index Terms: *sodium chloride, bitumen, bituminous mix, stability, aashto.*

GJRE-E Classification : *FOR Code: 090599, 290899*

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A. Chowdhury [α], K. M. Islam [σ], M. Z. Rahaman [ρ], & M. A. Sobhan [ω]

Abstract - Demand for modifications is increasing throughout the world parallel to develop the existing highway materials to fulfill the increasing demand of vehicles. Some materials produce good effect and enhance the strength as well as qualities of bitumen. On the other hand, some materials are responsible for adverse effect on the bitumen. In saline areas like coastal regions, the salt plays a significant role on the bituminous pavement. In this area, the most of the highways come to contact with salts content materials. In present study, the focus was given to find the various effects of salts on bitumen and bituminous mixers. A number of samples were prepared with addition of sodium chloride with respect to 2%, 4%, 6%, 8%, and 10% weight of bitumen. To determine its behavior and suitability, a variety of tests such as penetration test, softening point test, flash point and fire point test, ductility test, specific gravity test, solubility test etc. were conducted by standard ASTM method. It was observed from laboratory test that the penetration and specific gravity value are gradually increased and ductility, flash point, fire point, and softening point was gradually decreased due to the increase of salts content in a bituminous mix. To observe the effect of salt on stability of flexible pavement Marshall Mix design method was used with varying percentage of salt content. The stability value of bituminous mixes was decreased with increase the salt content in bitumen. From the consideration of stability, maximum 2% salt in bitumen can be allowed for road construction.

Index Terms: sodium chloride, bitumen, bituminous mix, stability, aashto.

I. Introduction

Bituminous mixes are most commonly used all over the world in pavement construction. Under normal circumstances, conventional bituminous materials if designed and executed properly perform quite satisfactory. But special applications like roundabouts or where traffic is extremely heavy, stiffer mixes are required which can have larger fatigue life and more resistance to permanent deformation. It has been found from many researches that the strength of the paving mixes can be enhanced by use of a binder formed by modifying available bitumen with certain additives like Sulphur [1], [2], rubber [3], [4], neoprene [5], polyethylene [6], [7] and organic polymer [8], [9]. In coastal area, pavement are quite often comes across with saline water. In this areas, the salt particularly sodium chloride plays an important role in the stability as well as durability of the road. In such a situation, the effects of salts on properties on the bitumen are vital for proper design and maintenance of the pavements. In this project, an attempt was taken to determine and compare the properties of salt mixed bitumen and pure bitumen and to investigate the behavior of bituminous mixes on stability with modified bitumen by increasing the percentage of salt in bitumen.

II. Materials and Methods

a) Sample Collection

The materials were used for specimen to compare the behavior of salt on engineering properties of bitumen are bitumen and sodium chloride. Sodium chloride salt originated from sea water was collected from the market of Rajshahi. The sodium chloride was tested for engineering properties related to flexible pavement. 80/100 grade bitumen without debris and adulterants was collected by eastern refinery company. The collected samples were modified with different percentage of salt content in laboratory and modified bitumen was used in the laboratory test.

b) Preparation of Samples

The samples were prepared by adding sodium chloride with pure bitumen. The amounts of salt were added by weight of percentage of pure bitumen separately. Five bowls was weighted for preparing sample. Hot bitumen was poured into those bowls. The weight of the bitumen was taken. The salt was weighted with respect to 0%, 2%, 4%, 6%, 8% and 10% weight of pure bitumen. The samples were prepared one after another. Thus five samples were prepared with variable salt contents for each test.

c) Tests on Bitumen

To judge the effect of salt on properties of bitumen as binders, a variety of tests (e.g. Penetration test, Ductility test, Softening point test, Specific gravity test, Flash point and fire point test, Float test, Viscosity test, Loss on heating test, Solubility test) have been

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specified by Institutions like ASTM, I.S.I., Asphalt Institute and B.S.I [10]. Here ASTM was followed and prepared samples were tested to determine above engineering properties of bitumen [10].

d) Bituminous Mix Design

Bituminous mix is a type of mix in which the aggregates are bounded together by bituminous material. A good bituminous paving mix should exhibit stability, durability, workability and skid resistance properties besides economy. The overall objective for the design of bituminous mixes, to determine the economical blend and grading of aggregates and corresponding bitumen content which would yield a mix [11].

e) Marshall Method

Bruce Marshall, formerly Bituminous Engineer with Mississippi State Highway Department, USA formulated Marshall Method for designing bituminous mixes. Marshall's test procedure was later modified and improved upon by U.S. Corps of Engineer through their extensive research and correlation studies. ASTM and other agencies have standardized the test procedure. Generally, this stability test is applicable to hot-mix design of bitumen aggregates with maximum size 2.5 cm. In Bangladesh, bituminous concrete mix is commonly designed by Marshall Method [10].

In this method, the resistance to plastic deformation of cylindrical specimen of bituminous mixer is measured when the same is loaded at the periphery at a rate of 5 cm per minute. The test procedure is used in the design and evaluation of bituminous paving mixes. There are two major features of the Marshall method of designing mixes namely; Density-void Analysis and Stability-flow Test [10]. The stability of the mix is defined as a maximum load carried by a compacted specimen at a standard temperature of 60˚C. The flow is measured as the deformation in units of 0.25mm between no load and maximum load carried by the specimen during stability test. In this test an attempt was made to obtain optimum binder content for the aggregate mix type and traffic intensity.

i. *Sample Collection*

The materials was used for Marshall test specimen to evaluate the characteristics of bituminous mixes in addition to the stability of flexible pavement are coarse aggregate, fine aggregate, mineral filler and bitumen. Boulders of 100-300 mm size were collected from Panchagar. These boulders were broken manually to the size of 25 mm and less. The aggregates passing through 25 mm sieve and other sieves where retained aggregates were collected are 20 mm, 12.5 mm, 9.5 mm, 4.75 mm and 2.36 mm [11]. The white stone aggregate was used with rather mix of black stone. Specific gravity of coarse aggregate was 2.64. Combination of Domar sand and Padma river sand was used as the main source of fine aggregate. The aggregates passing through 2.36mm sieve and other sieves where retained aggregates were collected are 600μm, 300μm, 150μm and 75μm [11]. It was collected from the Transportation Lab in RUET. Specific gravity of fine aggregate was 2.35. Mix of fine sand and stone dust finer than 0.075mm (No. 200) was used as filler in all mixes. It was the residuals received after sieving the fine aggregate by mechanical shaker. It was passed through 75μm sieve. Specific gravity of mineral filler was 2.30. The engineering properties of materials were justified according to the procedure specified by AASHTO T19 [12] and AASHTO T85 [13] standards. In order to study the effect of sodium chloride on the behavior of bituminous mix, Marshall Test specimens were prepared with four modified bitumen content (e.g. 0%, 2%, 4%, 6% weight of pure bitumen) with 50 blows for medium traffic road according to the standard procedure specified by AASHTO.

ii. *Preparation of Marshall Test Specimen*

The coarse aggregates, fine aggregates and the filler materials were proportioned and mixed specified gradation of mineral aggregates and bitumen binder as per IRG.29-1968 [14].The aggregates and filler was mixed together in the desired proportion as per the design requirements and fulfilling the specified gradation. The required quantity of the mix was taken so as to produce a compacted bituminous mix specimen of thickness 63.5mm approximately. Approximately 1100g of aggregates and filler was taken and heated to a temperature of 170˚C to 190˚C. The compaction mould assembly and rammer was cleaned and kept pre-heated to a temperature of 100˚C to 145˚C. The bitumen was heated to a temperature of 121˚C to 138˚C and the required quantity of first trial % of bitumen say, 5% by weight of mineral aggregate was added to the heated aggregate and thoroughly mixed using a mechanical mixer. The mixing temperature for 80/100 grade bitumen was around 154˚C. The mix was placed in a mould and compacted by rammer, with 50 blows on either side (Figure 1). The compacting temperature was about 138˚C. The compacted specimen thickness was 63.5mm. The weight of aggregate was taken may be suitably altered to obtain a thickness of 63.5±3.0mm. Three specimens were prepared at each trail bitumen content which may be varied at 0.5% increments up to about 4.0 to 6.0 percent [11]. Marshall Stability test was performed under loading range 10N to maximum 40KN (Figure 2).

Figure 1 : Photographic views of pedestal hammer and mould used in preparing Marshall Test Specimen

Figure 2 : Photographic view of Marshall Stability Testing

III. Result and Discussion

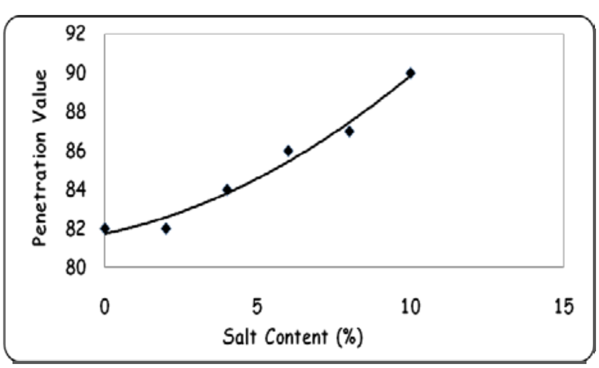

Figure 3 : Variation of penetration value with respect to salt content

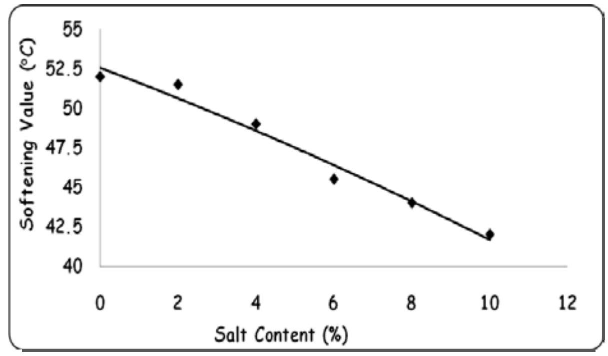

Figure 4 : Variation of softening value with respect to salt content

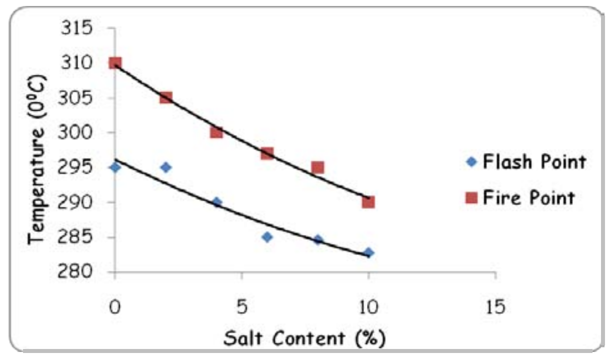

Figure 5 : Variation of flush and fire point value with respect to salt content

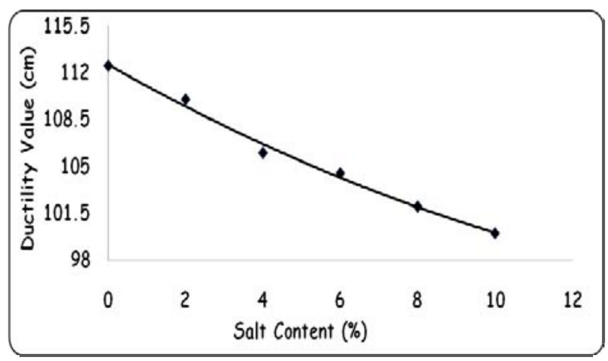

Figure 6 : Variation of ductility value with respect to salt content

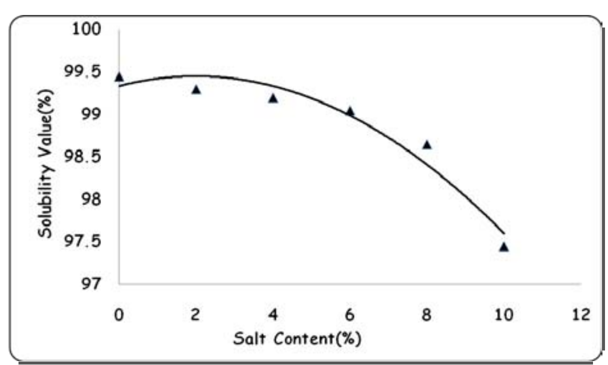

Figure 7 : Variation of solubility value with respect to salt content

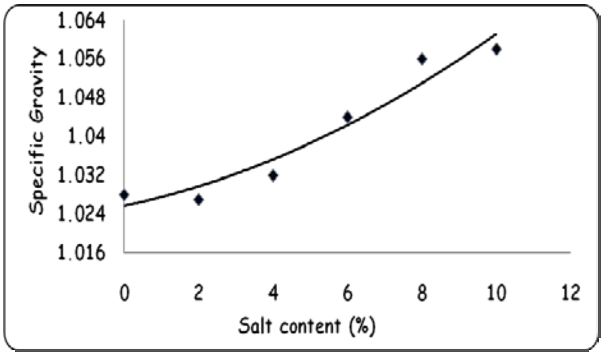

Figure 8 : Variation of Specific Gravity with respect to Salt Content

Figure3 indicates that the penetration value was increased after mixing of Salt content. Generally the penetration value of bitumen used for road construction in Bangladesh varies from 80 to 100. In warmer region lower penetration grades are preferred and in colder regions bitumen with higher penetration values are used [10]. So, bitumen with higher content of sodium chloride is suitable for colder region. Figure 4 shows that the variation of softening point with respect to salt content. The softening point of bitumen was decreased gradually with increasing the percentage of salt content. Limiting value of softening point of bitumen varies from 45oC to 50oC [10]. Bitumen with lower softening value may be preferred in colder regions. Another vital point on the test was flash point and fire point. It was seen from Figure 5 that fire point and flash point of bitumen was decreased. For lower flash point and fire point the worker has to be careful while heating the bitumen. A certain minimum ductility value is necessary for a bitumen binder. This is because the temperature changes in the bituminous mixes and the repeated deformation that occurs in flexible pavements due to traffic loads [10]. Bitumen with lower ductility value may cause crack especially in cold weather. The ductility value may vary from 15 to 100+, generally greater than 95. Figure6 shows that ductility value of bitumen was decreased with increasing the percentage of Salt content. Generally bitumen should be soluble in carbon disulfide (CS2) at least 99.5% [10]. But Figure7 shows that solubility value was decreased with the increase in Salt content. Figure8 indicates that specific gravity of bitumen was increased gradually with increase percentage of Salt content. This is due to the higher value of specific gravity of salt. Specific gravity of fresh bitumen varies from 1.022 to 1.06 [10].

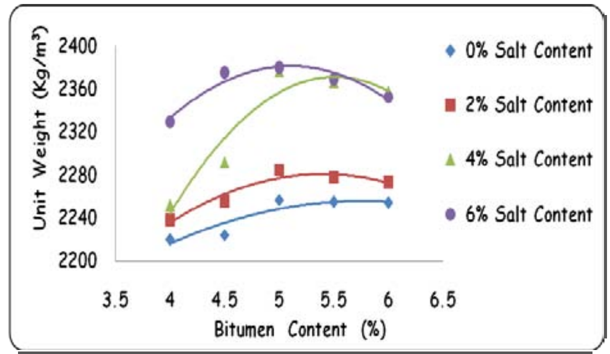

Figure 9 : Variation of unit weight with respect to modified bitumen content in percent

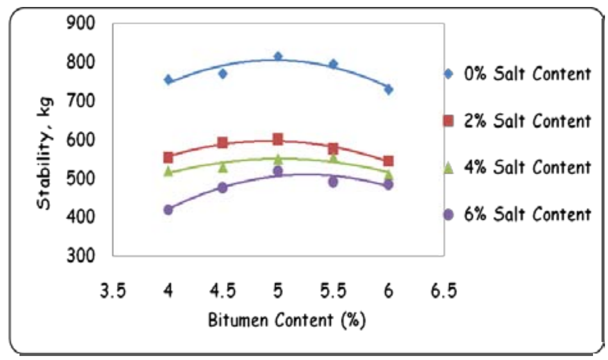

Figure 10 : Variation of stability value with respect to modified bitumen content in percent

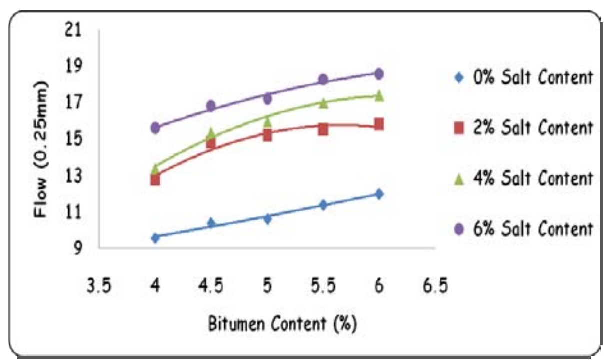

Figure 11 : Variation of flow (0.25mm) value with respect to modified bitumen content in percent

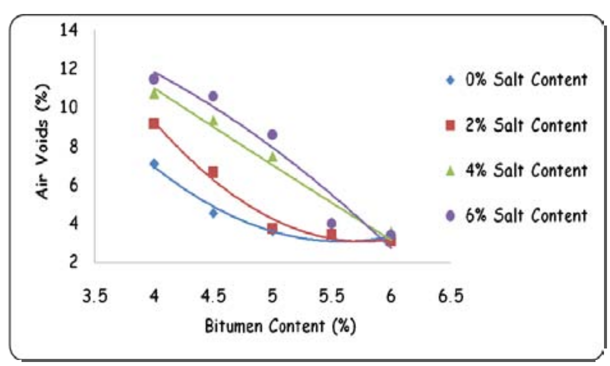

Figure 12 : Variation of percent air voids with respect to modified bitumen content in percent

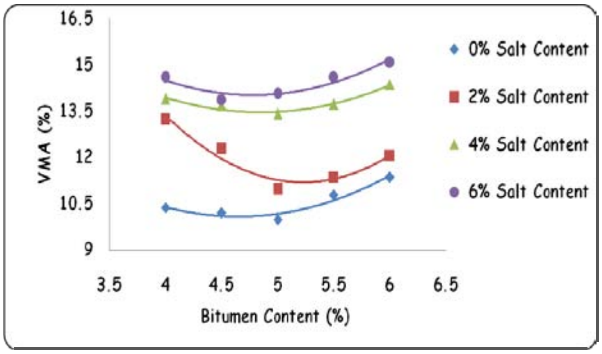

Figure 13 : Variation of % VMA with respect to modified bitumen content in percent

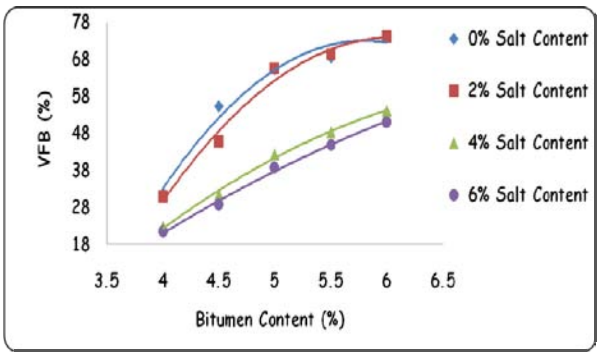

Figure 14 : Variation of % VFB with respect to modified bitumen content in percent

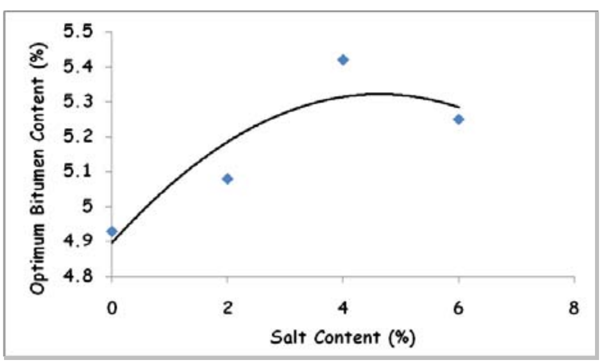

Figure 15 : Variation of optimum bitumen content at different percentage of salt content

From figure9, initially salt content in bitumen was less and voids in bituminous mix were filled with low dense particle. When salt percent in bitumen was increased then density also gradually increased reached a maximum value and after then it was goes downward because the aggregate particles was replaced with bitumen and hence density as well as unit weight was decreased. From figure10, initially percentage of salt content in bitumen was less and hence interlocking property remains good and stability was gradually increased reached a maximum value. Due to increment of salt content in bitumen the friction between bitumen and aggregate was less and aggregate try to be slide and hence stability was decreased. Deformation for max load is called flow value (figure11). Initially percent of salt content in bitumen was less as a result bonding between aggregate and bitumen is good, so flow value was also less. When salt content was increased gradually bond goes to weak due to friction between them and deformation was increased and flow value also increased. Percent Va means the air voids in compacted mix (figure12). Initially salt content in bitumen was less hence the maximum voids filled with air so %Va was high. When salt content was increased with bitumen then maximum voids filled with bitumen and less by air hence curve was gone downward. %VMA means volume occupied by the air and bitumen in compacted mix (figure13). Initially salt content in bitumen was less so maximum voids filled with air but total quantity was high. Due to the increase of salt content with bitumen voids filled with air and bitumen was equal hence curves gone to lowest point. Further increase of bitumen maximum voids filled with bitumen but lee by air then total quantity was high so %VMA again rises. The percentage of bitumen occupied the voids in VMA is called VFB (figure14). Initially salt content with bitumen was less hence %VFB also less and gradually increase the bitumen content and %VFB also increase. The optimum bitumen content was determined from figures of Marshall Test properties curves by taking the average of three bitumen contents at maximum unit weight, at maximum stability and at 4 percent (median of 3-5 percent range) air voids in total mix. From figure15 it was observed that the optimum bitumen content increases with the increase of salt content and was found maximum at 4% salt content in bituminous mix.

IV. Conclusions

Sodium chloride was played an important role in enhancement of the different properties of bitumen and bituminous mix design, as it is clear from test results and discussions. On the basis of the test results and subsequent discussions, it was concluded that the penetration value and specific gravity increases and softening point, flush & fire point, solubility and ductility of bitumen decreases with increasing salt in pure bitumen which indicated that the adhesion and cohesion properties of bitumen were reduced with increasing the percentage of salt in bitumen. The optimum bitumen content was also increased with increment of percentage of salt content and was found higher at 4% salt content. From Marshall Test, regarding the consideration of stability and durability of flexible pavement, maximum 2% salt in pure bitumen could be allowed for road construction.

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Effect of Size on Compressive Strength of Concrete Cylinder Specimens using Sand and Sulfur Cap

By A. Chowdhury, A. S. M. Z. Hasan, M. Z. Alam & A. A. Masum
University of Engineering & Technology, Bangladesh

Abstract- In the majority of structural concrete design, the compressive strength is obtained from testing of 150x300 mm concrete cylinders under standard laboratory controlled conditions with different capping system. Some testing machines are unable to produce the force needed to break high-strength 150x300 mm concrete cylinders. If 100x200 mm cylinders are to be used in quality assurance testing, the relationship between fc4 and fc6 needs to be understood in order to ensure that concrete with sufficient strength is provided. 100x200 mm cylinders are lighter and can easily be handled, collection of quality control and assurance specimens would be easier for contractors and inspectors. This research work was born from the need to determine a correlation between the strength of the standard size 150x300 mm and 100x200 mm cylindrical specimen. A total 72 no. of 100x200 mm and 150x300 mm cylinders were tested according to ASTM. Cylinders prepared by sand and sulfur capping reveals a little difference in the strength level, 150x300 mm and 100x200 mm sulfur capped cylinders shows 23% and 21% higher strength than sand capped cylinders and 100x200 mm cylinder gives 39% higher strength than 150x300 mm cylinder.

Index Terms: *size, compressive strength, sand cap, sulfur cap.*

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EFFECTOFSIZEONCOMPRESSIVESTRENGTHOFCONCRETECYLINDERSPECIMENSUSINGSANDANDSULFURCAP

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I. Introduction

Concrete is a versatile material with tremendous applications in civil engineering construction. Here test of compressive strength of concrete cylinder is done by two methods. One is sulfur capping method and another method is sand capping. Thus, capping at the end of concrete cylinder should satisfy the specific standards set forth in American Society for Testing and Materials (ASTM) in order to obtain accurate test results for the compressive strength of concrete. Sand-capping method, which is introduced in this study, uses a simpler device compared to other complicated sand-box system. It is to be shown that this new capping system is not only more economical in terms of the test time and process but more reliable in the test results than any other unbounded methods. These results are verified by the average compressive strength of concrete as compared to sand capping methods pursuant to ASTM C1231. The new trend of using high-strength concrete in construction has caused a need for 100 x 200 mm cylinders for assurance testing. Some testing machines are not able to produce the force needed to break high-strength 150 x 300 mm. concrete cylinders. As laboratories and testing agencies are very often equipped with testing machines having full load capacities no greater than 300,000 lb, the maximum compressive strength of concrete that can be tested on 150 x 300 mm. specimens is just over 10,000 psi when operating at full load, which is not safe on a routine basis [2]. The required force to break a 100 x 200 mm cylinder is 44% of that required to break a 150 x 300 mm cylinder of the same strength solely based on a ratio of the two circular cross-sectional areas [3]. This would allow machines that could not break 150 x 300 mm cylinders with strengths over 10,000 psi to break 100 x 200 mm cylinders with strengths in excess of 20,000 psi. A 100 x 200 mm cylinder weighs about 9 lb compared to a 150 x 300 mm. cylinder, which weighs about 30 lb, almost three times as much. This might suggest that because 100 x 200 mm cylinders are lighter and can easily be handled, collection and storage of quality control and assurance specimens would be easier for contractors and inspectors. One aspect of concern when using 100 x 200 mm cylinders is the size of maximum coarse aggregate used in concrete. Mixes containing a nominal maximum coarse aggregate size of 1.5 inches, or greater in some instances, are used in today's concrete industry. AASHTO T 126 states that, "the size of a cylinder mold shall not be smaller than 3 times the nominal maximum coarse aggregate size." This limits 100 x 200 mm cylinders to having a 1-inch nominal Maximum coarse aggregate size. Also there is no standard aggregate size between 1 inch and 1.5inches, leaving a #57 coarse aggregate the largest possible gradation for a 100 x 200 mm cylinder. The obvious advantages of using smaller specimens are: a) ease in handling and transportation; b) smaller required storage space; c) lower capacity required of testing machines; and d) the economic advantages of reduced costs for molds, capping materials, and concrete [3].

$$f_{csul} = k_s \times f_{csand} \quad (1)$$

$$f_{c4} = k_{si} \times f_{c6} \quad (2)$$

where,

f_{csul} = Compressive strength of a sulfur capped cylinder,

f_{csand} = Compressive strength of a sand capped cylinder,

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k_s= The strength conversion factor, correlating the sulfur and sand capped cylinder strength,

f_{c4}= Compressive strength of a 100 x 200 mm cylinder,

f_{c6} = Compressive strength of a 150 x 300 mm. cylinder,

k_{si}= The strength conversion factor, correlating the 100 x200 mm cylinder to the 150 x 300 mm cylinder strength.

II. Experimental Program

a) Mix Design Procedure

The use of locally available materials from different sources was emphasized in this work. Scan cement (Portland composite cement) and locally available brick chips were used for coarse aggregates. The mix proportion was 1:2:4 with a water-cement ratio of 0.4 [5]. At first sand and brick chips were screened by the sieve according to AASHTO T 22. Concrete constructions (Sand, Brick chips) were measured to dry separately by weight according to required proportions. The Brick chips were soaked thoroughly 24 hours and then made them surface dry saturated before use. Sand and cement were mix to dry on a clean platform until the mix was uniform. The coarse aggregate then added to mix of cement and sand admixture and the whole were mixed thoroughly. The moulds were lubricated by lubricating oil, before placing concrete in the mould.

b) Casting and Curing

All specimens were made and cured according to ASTM C192. All 150 x 300 mm cylinders were tamping with a rod for 25 times per layer for three layers of equal height and for 100 x 200 mm cylinders 25 times per layer for two layers of equal height. After strike-off, all specimens were moved from mixing room to curing room. The 36 cylinders were cured for 7days and rest 36 cylinders for 28 days. All the specimens were carefully cured by immersing in clean water on the water bath of the laboratory.

c) Capping Material and Method

Two kind of capping methods were used to compare the compressive strength of each specimen in this study. Sulfur and locally available white natural silica sand were used for capping the cylinder specimens. Molten sulfur compound capping was formed by a vertical capping apparatus as specified in ASTM C617. In sand capping method as suggested in this project the sand was placed at top of cylinder as simple capping devices. All of the dry fine sand was passed through NO.20 sieve for its use as a sand capping material.

d) Testing

In testing program the specimens were maintained in a moist condition up to the time of compression testing. Compression test are made as soon as practicable after removal from moist storage. The specimens were tetsed in this cured moist condition. Applying load was13.8 N/cm2 to 34.5N/cm2 and maintained the rate once adjusted until failure according to ASTM C 39.

III. Result and Discussion

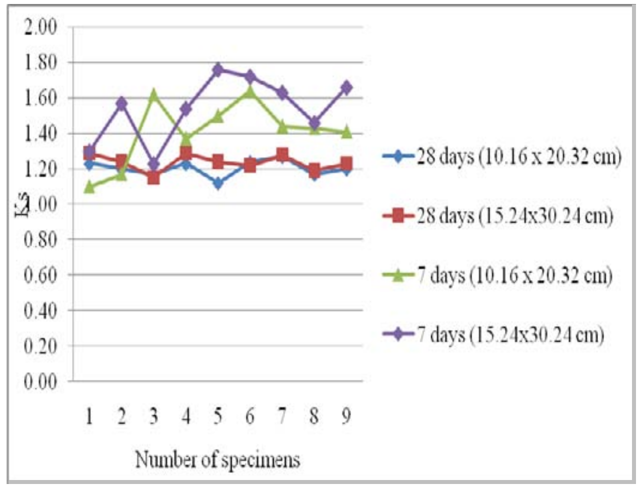

Figure 1 : Comparison of Ks with all ages

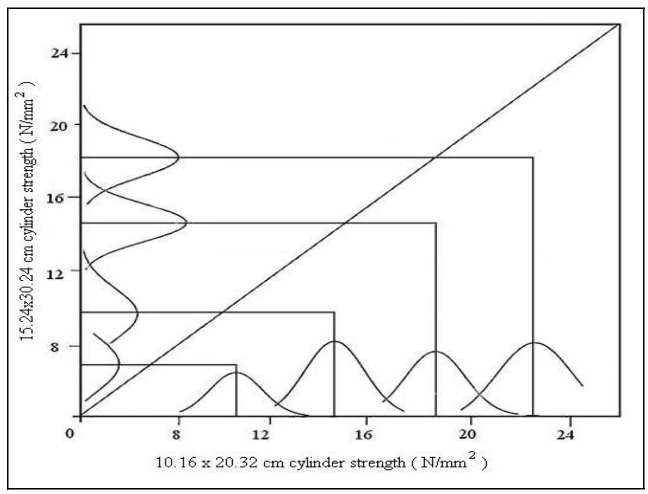

Figure 2 : Normal distributions of test results

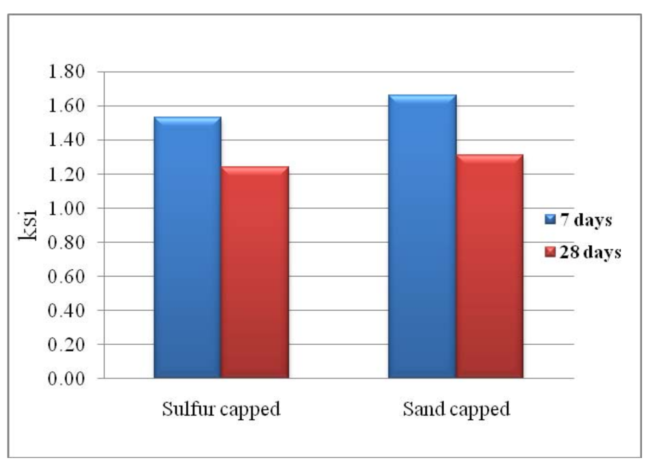

Figure 3 : Strength conversion factor Ksi

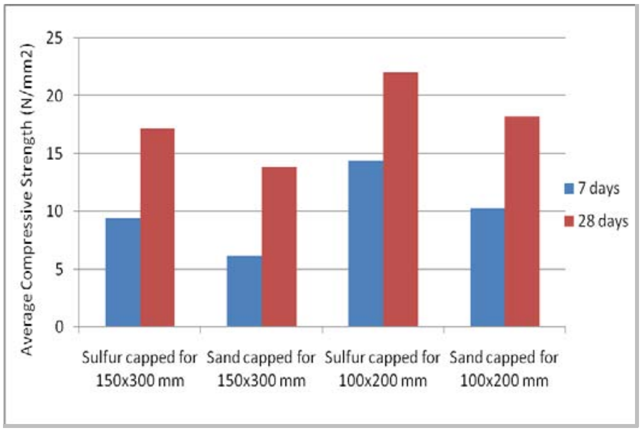

Figure 4 : Average Compressive Strength (N/mm2)

From the test results by using individual frequency distribution the standard deviation of Sand capping vs. sulfur capping for 7 days and 28 days were calculated and analyzed in the Table 2 and Table 3. From figure 1, the value of ks is more consistent for 28 days of 150 x 300 mm cylinders and it also gives more consistence results then the 100 x 200 mm cylinders. Figure 2 shows the normal distributions for the two types of cylinders. For 100 x 200 mm cylinder normal distributions was plotted on the horizontal axis and for 150 x 300 mm cylinder on the vertical axis. Lines representing the mean of each distribution extend outward until they intersect with the mean line of the opposite cylinder size for the same strength range. This was done to plot the intersections of the means of each distribution against a 450 line of equality. It was seen that the mean compressive strengths for each strength range increased with age. The intersection of the means is an indicator of the magnitude of ksi. If the intersection is below the line of equality, then the strength is in favor of the 100 x 200 mm cylinders and ksi is greater than 1.0. If the intersection is on the line of equality, then the strengths are equal and ksi is equal to 1.0. If the intersection is above the line of equality, then the strength is in favor of the 150 x 300 mm. cylinders and ksi is less than 1.0. From figure 2, ksi is greater than 1 for each type cases. Figure 3 represent the strength conversion factor ksi which is the ratio of 100 x 200 mm to the 150 x 300 mm concrete cylinders. From the test results the sulfur capped specimen's was given higher strength for 28 days and in average the compressive strength of 100 x 200 mm cylinder is 39% to 48% higher than 150 x 300 mm cylinders.

IV. Verification of Test Result

The test results from figure 4 were sampled to investigate the average compressive strength of the test cylinders except underrated (outlier) data to excessive cap-thickness, imperfect capping or failure caused by electric loading. The statistical confidence level of 95% was set so that the results are to be statistically acceptable at α=0.050. The average compressive strength obtained by bonded capping should not be less than 98% of that obtained by unbonded capping methods. The calculation process for verifying the unbonded capping system involved the following. For every strength group, the difference in strength of cylinders (sulfur capped vs. sand capped cylinders) was computed. Next, it was verified that the average strengths of the two kinds of bonded capping cylinders were over 98% of those unbonded capping cylinders.

$d_i = X_{sulfur\ i} - X_{sand\ i}$

$$X_{sulfur} = (X_{s1} + X_{s2} + X_{s3} + X_{s4} + \ldots.. + X_{sn})/n$$

$$X_{sand} = (X_{s1} + X_{s2} + X_{s3} + X_{s4} + \ldots.. + X_{sn})/n$$

where,

d_i = Difference in strength of cylinders

$X_{sulfur\ i}$ = Cylinder strength using sulfur capping

$X_{sand\ i}$ = Cylinder strength using unbonded capping

n = Number of combination of cylinder

X_{sulfur} = Average strength of sulfur capped cylinders.

X_{sand} = Average strength of sand capped cylinders

Average difference, $d = (d_1 + d_2 + d_3 + \ldots\ldots + d_4)/n$

Standard deviation, $S_d = [\sum(d_i-d)^2/(n-1)]^{1/2}$

In order to comply the practice for ASTM C 617[11], the following relationship must be satisfied,

$$X_{sulfur} \geq 0.98\ X_{sand} + (t.S_d)/(n)^{1/2} \text{ for 7 days}$$

$$X_{sulfur} \geq 0.98\ X_{sand} + (t.S_d)/(n)^{1/2} \text{ for 28 days}$$

Where, t is the value of 'student's t-test for (n-1) pairs at significant level of α=0.050 as shown in the Table 1.

Use linear interpolation for other values of (n-1) or refer to appropriate statistical tables. The calculation process and results was shown in table below for the verification of test results. All the compressive strength of cylinders by bonded capping methods exhibit greater than 98% of the reference values of all specimens.

Table 1 : The value of t

(n-1)	t (α=.050)
9	1.83
14	1.76
19	1.72
100	1.66

Table 2 : Statistical analyses of test results for 150 x 300 mm cylinders

Capping types	Calculation (N/mm^2)	Values
Sand capping vs. sulfur capping For 7 days	(1) X_{sulfur}	9.41
	X_{sand}	6.18
	d	3.25
	S_d	0.83
	(2)$0.98X_{sand}+(t\ S_d)/(n)^{1/2}$	6.4
	System qualifies (1)>(2)	ok

Sand capping vs. sulfur capping For 28 days	(1) X_{sulfur}	17.17
	X_{sand}	13.89
	d	3.3
	S_d	0.55
	(2)$0.98X_{sand}+(t\ S_d)/(n)^{1/2}$	13.84
	System qualifies (1)>(2)	ok
	n=18,t=1.7418	

Table 3 : Statistical analyses of test results for 100 x 200 mm cylinders

Capping types	Calculation (N/mm^2)	Values
Sand capping vs. sulfur capping For 7 days	(1) X_{sulfur}	14.4
	X_{sand}	10.28
	D	4.12
	S_d	1.63
	(2)$0.98X_{sand}+(t\ S_d)/(n)^{1/2}$	10.74
	System qualifies (1)>(2)	ok
Sand capping vs. sulfur capping For 28 days	(1) X_{sulfur}	22.01
	X_{sand}	18.24
	D	3.77
	S_d	0.78
	(2)$0.98X_{sand}+(t\ S_d)/(n)^{1/2}$	18.12
	System qualifies (1)>(2)	ok
	n=18,t=1.7418	

V. Conclusions

Strength of concrete cylinder was obviously affected by capping method. Strength variation due to various methods exhibited a different tendency for normal and high strength level. The standard deviation of sand capped was less than sulfur capped cylinders. The comparison of compressive strength of cylinders prepared by sand capping and sulfur capping reveals a little difference in the strength level. In the 150 x 300 mm sulfur capped cylinders the difference in strength was 19% higher than those prepared by sand capping for 28 days and 34% higher than those prepared by sand capping for 7 days, and for 100 x 200 mm cylinders these values were 17% and 29% higher respectively. The 100 x 200 mm cylinder was given 38% to 48% higher strength than 150 x 300 mm cylinder. It was found that each strength range had its own range of ksi values and that ksi decreased with increasing compressive strength ranges.

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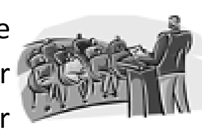

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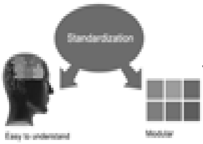

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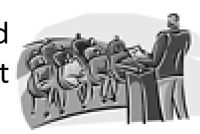
Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as "Institutional Fellow of Open Association of Research Society" (IFOARS).

The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA)
The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.
The author fees of such paper may be waived off up to 40%.



The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

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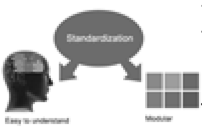

After nomination of your institution as “Institutional Fellow” and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

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- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
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Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone. "

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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript’s Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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Research letters: The letters are small and concise comments on previously published matters.

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The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

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(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

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(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

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Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

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References

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24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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