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Journal Information

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TABLE OF CONTENT

Investigation and Comparative Analysis of Clay Content, Grain Size and Grain Size Distribution of Foundry Moulding Sands *Adekunle A. Yekinni, Solomon.K. Bello*	**5**
Tracing Sources of Indigenous Knowledge on Building elements of Historic Structures: The Case of Bagamoyo Building Heritage Site in Tanzania *Charles Lucian, Samwel Alananga*	26
Towards Effective use of Information and Communication Technology (ICT) Application in the Healthcare Management: A Descriptive Study of Online Appointment System Services of Hospitals in India. *M.S. Bexci, Dr. R. Subramani*	53

Investigation and Comparative Analysis of Clay Content, Grain Size and Grain Size Distribution of Foundry Moulding Sands

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Abstract

The chemical composition, clay content, grain size and grain size distribution (sieve analysis) of silica sands in six locations in Lagos area (South West, Nigeria) used in most foundry industries in Lagos and its environments as moulding sand for casting were investigated. The aim was to carry out comparative analysis of the sands and determine their suitability for casting both ferrous and non ferrous metals. Silica sand samples were collected at random from six major deposit of silica sand used by a leading Foundry industry based in Lagos, namely: Ajido, Araromi, Badagry, Epe, Gbelejo and Oworonsoki areas in Lagos beaches. The corresponding values of active clay contents for Ajido, Araromi, Badagry, Gbelejo and Oworonsoki are 0.3%, 0.76%, 0.85%, 0.55%, 0.60% and 0.84% respectively. These results showed that Ajido silica sand with lowest active clay contents would require highest binders while Badagry silica sand with highest active clay content would require least binders. However, these active clay contents fall within acceptable limit for moulding sand. Average Grain fineness number of 74.92, 76.22, 68.67, 80.64, 31.98 and 62.37 were obtained for Ajido, Araromi, Badagry, Epe, Gbelejo and Oworonsoki respectively. The results were presented in tabular and graphical forms to further analyse the grain size distribution. Effects of clay content on amount of binders and A.F.S grain fineness number on grain size and grain size distribution of each sample on green compressive strength, compactability and permeability were discussed.

Keywords: Silica sand, casting, active clay content, grain size distribution, A.F.S grain fineness number.

Introduction

Silica sand is evaluated for industrial use on the basis of its composition and physical properties (Mclaws 1971). Silica sand is commonly used in green sand system because of its low cost and availability. Green sand allows the steam from the sand to escape when the molten metal comes into contact with mould (The navy foundry manual 2002). According to shape, moulding sands can be classified as rounded, sub-angular and compound. Moulding sands composed of angular grains need higher amounts of binder, and moisture because of their greater specific surface area. Compound grains also require higher amount of binder and moisture. Compound grains are least desirable to sand mixtures because they have a tendency to disintegrate at high temperature (Sinha & Goel 1991).

Sand moulds are designed to have a good collapsibility and accommodate shrinkage of cast metal during solidification to avoid defects in the cast metal. Casting sand should have good

flowability to pack well during moulding to produce good surface finish as well as exhibition of lower permeability to give a better as-cast finish (Higginbs 1983). The quality of sand cast products are high (Rzydon 2008) as the sand mould can withstand high melting temperature of the cast metal. As casting size increases, more gas is produced in the mould, implying that the permeability of the sand must be higher. Burns 1986 reported that green sand is mostly used for large casting (450kg) while dry sand is usually for smaller casting (25kg).

Silica sand (SiO_2) is found as natural deposits in many beaches in Lagos area. Although pure silica is not suitable in itself for moulding and it has to be mixed with clay or carbon since it lacks binding qualities. Aweda et al 2009 reported in their paper that Abolarin et al 2007 once produced some samples of brake disc without any additives and found that the cast yield was high with minimal surface defect and that knowledge of the heating rates of sand moulds would help reduce the occurrence of defects generated by internal stresses due to high operating temperature (Solenik et al 2009).

As expected of any natural silica sand, the Ajido, Araromi, Badagry, Epe, Gbelejo and Oworonsoki silica sand deposit in Lagos area would not be adequately bonded with clay and therefore need some binders to cast ferrous and non ferrous metals. For Alumino-silicate sand to be suitable for non-ferrous alloy casting, 2.5% bentonite clay, 1.0% kaolin clay with about 2% moisture content are requited (Ademoh, 2008).

A grain size distribution plot is a special purpose graph generally used to depict the results of a sieve analysis, commonly known as a "gradation test". The sieve analysis determines the gradation (the distribution of aggregate particles, by size, within a given sample) in order to determine compliance with design, production control requirements, and verification specifications.

A sieve analysis (or a gradation test) is a practice or procedure used to assess the particle size distribution of a granular material (Wikipedia).

Statement of the Problem

Moulding sand is the most common material in casting process because of its certain inherent properties e.g. refractoriness, chemical and thermal stability at higher temperature, high permeability, and workability along with good strength. Moreover it is also cheap and easily available. Foundry Industries in Lagos rely on supply of moulding sands from various beaches in Lagos. However, these moulding sands are of varying chemical compositions, grain sizes and active clay content. The ever increasing demand for higher degree of accuracy and good surface finish of castings necessitates certainty in the quality of foundry sands. Therefore the needs to examine the clay content and carry out sieve analysis become necessary.

Aims of the Study

The aim of this study is to control the moulding sand preparation to impart consistent sand properties to the sand being delivered to the moulding unit. This is to be achieved by collecting samples from major deposit in the following areas in Lagos: Ajido, Araromi, Badagry, Epe, Gbelejo, and Oworonsoki. Chemical composition, active clay content, grain size and grain size distribution tests are to be carried out on each sample and the results compared from which the best sample is chosen and recommendations are made on the best use by the foundry industries.

Significance of The Study

Close examination, clay content and sieve analysis of moulding sand ensure the following:

Lower cost of materials: These tests would allow the use of less expensive local sands. It also ensures reliable sand mixing and enables a fuller utilization of the inherent properties of moulding sands.

Less number of rejects: The tests would help to detect any variation from standard quality, and adjustment of the sand mixture to specific requirement can be made.

Improved surface finish: Such tests allow the choice of sand to give a desired surface finish.

Scope and Limitation of the Study

The scope of this study is limited to the determination of chemical composition, investigation and comparative analysis of active clay content and grain size distribution. However, it is important to know that isolated sand tests give insufficient information on the consistency of foundry sand, and it is necessary to determine a full range of tests including ignition figures and grading before sand can be confirmed as having suitable properties for the particular plant and size of casting. Further studies on this subject would involve determination of moisture content, permeability, green strength, shatter index etc.

Literature Review

Chemical composition of moulding sand

Silica is the main constituent but along with silica small amounts of iron oxide, alumina, limestone, magnesia, manganese oxide, soda and potash are present as impurities.

The chemical compositions of a moulding sand give an idea of the impurities like lime, magnesia, alkalis etc, present, and thereby of the refractoriness of the sand. The present of excessive amounts of iron oxide, alkalis oxides and lime can lower the fusion point to a considerable extent which is not desired (Sinha & Goel 1991).

Grain size of moulding sand

The grain size influences the properties of sands as follows:

Compactability: Finer the sand, the lower is the compactability and vice versa. This results from the fact that the specific surface increases as the grain size decreases. As a result, the number of points of contact per unit volume increases and this in turn raises the resistance to compacting.

Green strength: The green strength has a certain tendency, admittedly not very pronounced, towards a maximum with a grain size which corresponds approximately to the medium grain size. As the grains become finner, the film of bentonite becomes thinner, although the percentage of bentonite remains the same. Due to the thinning of bentonite film, the green strength is reduced. With very coarse grains, however, the number of grains and, therefore, the number of points of contact per unit of volume decreases so sharply that the green strength is again reduced.

Permeability: The sands with grains equal but coarse in size have greater void space and have therefore, greater permeability than the finer sands. This is more pronounced if the sand grains are equal in size (Sinha & Goel 1991).

Grain size distribution of moulding sand
The grain size distribution influences the properties of the sand as follows:

Compactability: Sand with wide range of particle size has higher compactability than sand with narrow distribution. The broadening of the size distribution may be done either to the fine or coarse side of the distribution or in both directions simultaneously and a sand of higher density will result. Broadening to the coarse side has a great effect on density than broadening the distribution to the fine side.

Green strength: A wide range distribution favours the green strength while narrow grain distributions reduce it.

Permeability: The grain size distribution has a pronounced effect on permeability. A sand containing many fines and a wide range of particle size (i.e. wide distribution) will have low permeability as compared to that containing grains of average fineness but of the same size (i.e. narrow distribution) (Sinha & Goel 1991).

Particle Size & Sand Sieve Analysis
□□□Particle Size Analysis: % Sand, % Silt, % Clay, and Textural Class
□□□Sand Sieve Analysis: Seven separations will be reported in percent according to the following table:

Table 1: Particle size and sieve analysis

SOIL SEPARATE	DIAMETER RANGE (MM)	US STANDARD SIEVE NO
GRAVEL	2.0 and larger	10
VERY COARSE SAND	2.0-1.0	18
COARSE SAND	1.0-0.5	35
MEDIUM SAND	0.5-0.25	60
FINE SAND	0.25-0.10	140
VERY FINE SAND	0.10-0.05	270
FINES	Less than 0.05	-

Source: Agricultural Analytical Services Laboratory. The Pennsylvania State University

Foundry sands usually fall into the range of 150-400µm, with 220-250µm being the most commonly used. Direct conversion between average grain size and AFS grain fineness number is not possible, bur an approximate relation is shown below:

Table 2: Relation between AFS grain fineness number and Average grain size

AFS grain fineness no	35	40	45	50	55	60	65	70	80	90
Average grain size (µm)	390	340	300	280	240	220	210	195	170	150

Source: Foseco Ferrous Foundryman's Handbook.

While average grain size and AFS grain fineness number are useful parameters. Choice of sand should be based on particle size distribution

Limitations of Sieve Analysis

Sieve analysis has, in general, been used for decades to monitor material quality based on particle size. For coarse material, sizes that range down to #100 mesh (150μm), a sieve analysis and particle size distribution is accurate and consistent.

However, for material that is finer than 100 mesh, dry sieving can be significantly less accurate. This is because the mechanical energy required to make particles pass through an opening and the surface attraction effects between the particles themselves and between particles and the screen increase as the particle size decreases. Wet sieve analysis can be utilized where the material analyzed is not affected by the liquid - except to disperse it. Suspending the particles in a suitable liquid transports fine material through the sieve much more efficiently than shaking the dry material (British Standard Institute, 1976).

Sieve analysis assumes that all particles will be round (spherical) or nearly so and will pass through the square openings when the particle diameter is less than the size of the square opening in the screen. For elongated and flat particles a sieve analysis will not yield reliable mass-based results, as the particle size reported will assume that the particles are spherical, where in fact an elongated particle might pass through the screen end-on, but would be prevented from doing so if it presented itself side-on. (Wikipedia, the free encyclopedia 2011).

Research Methodolgy

This study was experimental and involves determination of clay content and mechanical sieve analysis to determine the average grain size and grain size distribution of sand specimens.

Clay grade and sieve analysis are two separate tests, but as it is necessary to do a clay grade determination on sand before the sieve analysis is done, both are considered as sections of one test. It is important to know the clay grade, as this gives an indication of the binder content present. According to Sinha & Goel 1991, if a sieve analysis is carried out on the sand without removal of the clay, a false result will be obtained.

Grain size distribution gives an indication of suitability of moulding sand to withstand various mechanical properties like compactability, shatter index, green strength, permeability etc.

Materials And Methods

Sand samples were taken from six different supplies of silica sand in Nigerian Foundries Lagos where the tests were carried out. Other materials include Oven, Weighing scale, Variable-Speed test sieve shaker and water.

Table 3: Chemical composition of silica sand samples

CHEMICAL COMPOSITION	AJIDO %	ARAROMI %	BADAGRY %	EPE %	GBELEJO %	OWORONSOKI %
SiO_2	89.50	87.05	90.20	88.70	88.10	89.06

Al_2O_3	3.62	4.75	5.26	4.17	6.65	6.22
Fe_3O_2	2.04	2.64	0.68	1.21	0.91	0.67
TiO_2	0.19	0.10	0.17	0.08	0.12	0.11
CaO	0.63	0.52	0.58	0.73	0.68	0.61
MgO	0.28	0.46	0.32	0.31	0.62	0.82
Na_2O	0.17	0.36	0.27	0.31	0.52	0.33
K_2O	1.23	1.32	1.02	1.82	1.12	0.88
MnO	-	0.01	-	0.03	-	-
Loss on Ignition	1.13	1.34	1.11	0.83	0.77	1.03

Source: Research data, 2013

Determination of Clay Contents and Sieve Grading

200g of each sand sample was weighed out and dried completely at about 150^0C. It was allowed to cool and weighed. The clay content was washed away by adding water to the dried sample. The clay free sample was dried completely again and allowed to cool and weighed.
Sieve analysis is conducted by weighing out 100g of sand from the sand sample now free of clay. The clay-free sample is placed in the top sieve of variable-speed test sieve shaker for about 3 minutes. The sieves are removed from the shaker, and then separated, and the sand retained on each sieve weighed. The grain size and grain size distribution influence the properties of the sand such as shatter index, compactability, permeability and green strength while the clay content is used to determine the extent of binder required in moulding sand.

Results

Table 4 presents the results obtained from clay content determination of the six sand samples. While tables 5a, b, c, d, e, f present grain distribution and calculation of A.F.S grain fineness number from mechanical sieve analysis of the silica sand samples. The results from mechanical sieve analysis are further presented in tables 6a, b, c, d, e, and f to show the variation of mesh diameter with cumulative percent retained. The amount and type of clay have a great influence on the strength and other properties of moulding sand. The permeability decreases with increasing clay content. The green compressive strength first increases with the increase in clay content. But after a certain value, it is expected to start decreasing (Sinha & Goel 1991). The determination of grain fineness number provides a rapid method for expressing the average grain size and is of value in comparing various grades of sands from a given deposit having similar grain distribution. It enables the control of system or heap sand in foundry. The limitation of this number is that this number is in no way an index of the distribution of the sand grains. Sands having the same grain fineness number need not be of the same grade.

Hence, a more reliable method for assessing the suitability of a sand sample from the view point of size distribution is to plot % values (by weight of sand retained in sieves of different mesh sizes as cumulative grading curves. The nature of the cumulative grading curve is independent of the type of standard sieves used.

The results from table 5a-f are presented in graphical plots as shown in figure 1a-g while figure 2a-g represents the results in table 6a-f.For control purposes it is essential that test results are recorded graphically on a chart to indicate whether sand properties are being kept within the prescribed limit, but more important, whether there are any tendencies towards poor conditions in the sand.

Grain size distribution plot is a special purpose graph generally used to depict the results of a sieve analysis, commonly known as a "gradation test". The sieve analysis determines the gradation (the distribution of aggregate particles, by size, within a given sample) in order to determine compliance with design, production control requirements, and verification specifications.

Table 4: Clay Content of samples

SAMPLE	SAMPLE WEIGHT DRY (g)	SAMPLE WEIGHT WASHED (g)	CLAY CONTENTS (g)	CLAY CONTENT (%)
Ajido	188.6	188.0	0.6	0.30
Araromi	182.4	181.0	1.4	0.76
Badagry	189.0	187.3	1.7	0.85
Epe	189.2	188.1	1.1	0.55
Gbelejo	181.6	180.4	1.2	0.60
Oworonsoki	188.6	187.0	1.6	0.84

Source: Research data, 2013

Table 5a: A.F.S Grain fineness number of Ajido Silica Sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Multiplier	Product
1.400	0.00	0.00	6	0.00
1.000	0.00	0.00	9	0.00
0.710	0.30	0.30	15	4.50
0.500	0.80	0.80	25	20.00
0.355	1.50	1.50	35	52.00
0.250	7.70	7.70	45	346.50
0.180	37.00	37.00	60	2220.00
0.125	49.60	39.60	81	3207.60
0.090	10.60	10.60	118	1250.80
0.063	1.60	1.60	164	262.40
Sieve Pan	0.30	0.30	275	82.50
Total		99.40		7446.80

Source: Research data, 2013

A.F.S grain fineness number = $\frac{744.68}{99.40}$ = 74.92

Table 5b: A.F.S Grain fineness number of Araromi Silica Sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Multiplier	Product
1.400	0.00	0.00	6	0.00
1.000	0.10	0.10	9	0.90
0.710	0.60	0.60	15	9.00
0.500	2.80	2.80	25	70.00
0.355	3.30	3.30	35	115.50
0.250	8.40	8.40	45	1378.00
0.180	27.60	27.60	60	1656.00

0.125	37.80	37.80	81	3061.80
0.090	12.60	12.60	118	1486.80
0.063	2.10	2.10	164	344.40
Sieve Pan	0.70	0.70	275	195.50
Total		96.00		7317.10

Source: Research data, 2013

A.F.S grain fineness number = $\frac{7317.10}{96.00}$ = 76.22

Table 5c: A.F.S Grain fineness number of Badagry silica sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Multiplier	Product
1.400	0.00	0.00	6	0.00
1.000	0.00	0.00	9	0.00
0.710	0.30	0.30	15	4.50
0.500	1.10	1.10	25	27.50
0.355	2.30	2.30	35	80.50
0.250	20.00	20.00	45	900.00
0.180	36.60	36.60	60	2196.00
0.125	29.60	29.60	81	2397.60
0.090	7.90	7.90	118	932.20
0.063	1.10	1.10	164	164.00
Sieve Pan	0.40	0.40	275	110.0
Total		99.20		6812.10

Source: Research data, 2013

A.F.S grain fineness number = $\frac{6812.10}{99.2}$ = 68.67

Table 5d: A.F.S Grain fineness number of Epe silica sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Multiplier	Product
1.400	0.00	0.00	6	0.00
1.000	0.00	0.00	9	0.00
0.710	0.00	0.00	15	0.00
0.500	0.40	0.40	25	10.00
0.355	0.90	0.90	35	31.50
0.250	6.90	6.90	45	310.50
0.180	31.40	31.40	60	1884.00
0.125	37.40	37.40	81	3029.40
0.090	16.80	16.80	118	1982.40
0.063	2.40	2.40	164	393.60
Sieve Pan	0.60	0.60	275	165.00
Total		96.80		7806.40

Source: Research data, 2013

A.F.S grain fineness number = $\frac{7806.40}{96.8}$ = 80.64

Table 5e: A.F.S Grain fineness number of Gbelejo Silica Sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Multiplier	Product
1.400	5.00	5.00	6	48.00
1.000	9.50	9.50	9	85.50
0.710	12.20	12.20	15	183.00
0.500	18.50	18.50	25	462.50
0.355	19.70	19.70	35	689.50
0.250	22.40	22.40	45	1008.00
0.180	7.50	7.50	60	450.00
0.125	1.80	1.80	81	145.80
0.090	0.20	0.20	118	23.60
0.063	0.00	0.00	164	0.00
Sieve Pan	0.00	0.00	275	0.00
Total		96.80		3095.90

Source: Research data, 2013

A.F.S grain fineness number = $\frac{3095.90}{96.8}$ = 31.98

Table 5f: A.F.S Grain fineness table of Oworonsoki silica sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Multiplier	Product
1.400	0.00	0.00	6	0.00
1.000	0.00	0.00	9	0.00
0.710	0.00	0.00	15	0.00
0.500	0.50	0.50	25	12.50
0.355	0.90	0.90	35	31.50
0.250	5.80	5.80	45	261.00
0.180	28.80	28.80	60	1296.00
0.125	36.10	36.10	81	2166.00
0.090	21.60	21.60	118	1749.60
0.063	1.80	1.80	164	212.40
Sieve Pan	0.60	0.60	275	165.00
Total		96.1		5994.00

Source: Research data, 2013

A.F.S grain fineness number = $\frac{5994.00}{96.1}$ = 62.37

Table 6a: Cumulative grading table of Ajido Silica Sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Cumulative % retained
1.400	0.00	0.00	0.00
1.000	0.00	0.00	0.00
0.710	0.30	0.30	0.30
0.500	0.80	0.80	1.10
0.355	1.50	1.50	2.60
0.250	7.70	7.70	10.30

0.180	37.00	37.00	47.30
0.125	39.60	39.60	86.90
0.090	10.60	10.60	97.50
0.063	1.60	1.60	99.10
Sieve Pan	0.30	0.30	99.40
Total		99.40	

Source: Research data, 2013

Table 6b: Cumulative grading table of Araromi Silica Sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Cumulative % retained
1.400	0.00	0.00	0.00
1.000	0.10	0.10	0.10
0.710	0.60	0.60	0.70
0.500	2.80	2.80	3.50
0.355	3.30	3.30	6.80
0.250	8.40	8.40	15.2
0.180	27.60	27.60	42.8
0.125	37.80	37.80	80.60
0.090	12.60	12.60	93.20
0.063	2.10	2.10	95.30
Sieve Pan	0.70	0.70	96.00
Total		96.00	

Source: Research data, 2013

Table 6c: Cumulative grading table of Badagry silica sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Cumulative % retained
1.400	0.00	0.00	0.00
1.000	0.00	0.00	0.00
0.710	0.30	0.30	0.30
0.500	1.10	1.10	1.40
0.355	2.30	2.30	3.70
0.250	20.00	20.00	23.70
0.180	36.60	36.60	60.30
0.125	29.60	29.60	89.90
0.090	7.90	7.90	97.80
0.063	1.10	1.00	98.80
Sieve Pan	0.40	0.40	99.20
Total		99.20	

Source: Research data, 2013

Table 6d: Cumulative grading table of Epe silica sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Cumulative % retained
1.400	0.00	0.00	0.00
1.000	0.00	0.00	0.00

0.710	0.00	0.00	0.00
0.500	0.40	0.40	0.40
0.355	0.90	0.90	1.30
0.250	6.90	6.90	8.20
0.180	31.40	31.40	39.60
0.125	37.40	37.40	77.00
0.090	16.80	16.80	93.80
0.063	2.40	2.40	96.20
Sieve Pan	0.60	0.60	96.80
Total		96.80	

Source: Research data, 2013

Table 6e: Cumulative grading table of Gbelejo Silica Sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Cumulative % retained
1.400	5.00	5.00	5.00
1.000	9.50	9.50	14.50
0.710	12.20	12.20	26.70
0.500	18.50	18.50	45.20
0.355	19.70	19.70	64.90
0.250	22.40	22.40	87.30
0.180	7.50	7.50	94.80
0.125	1.80	1.80	96.60
0.090	0.20	0.20	96.80
0.063	0.00	0.00	96.80
Sieve Pan	0.00	0.00	96.80
Total		96.80	

Table 6f: Cumulative grading table of Oworonsoki silica sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Cumulative % retained
1.400	0.00	0.00	0.00
1.000	0.00	0.00	0.00
0.710	0.00	0.00	0.00
0.500	0.50	0.50	0.50
0.355	0.90	0.90	1.40
0.250	5.80	5.80	7.20
0.180	28.80	28.80	36.00
0.125	36.10	36.10	72.10
0.090	21.60	21.60	93.70
0.063	1.80	1.80	95.50
Sieve Pan	0.60	0.60	96.10
Total		96.10	

Source: Research data, 2013

Discussion

Clay Content: Badagry and Araromi silica sands have the highest clay content of 0.85% and 0.84% respectively while Epe silica sand has the lowest of 0.3%. Since the higher the clay content the lower the binder content required and vice-versa. It can be deduced that Badagry and Araromi silica sands would require minimum amount of binders while Epe silica sand requires the highest amount of binders. However, Badagry and Araromo silica sand with high clay content will have low permeability and high compressive strength

Table 6: Clay content classification

SILICA SAND TYPE	COMPACTABILITY	GREEN STRENGTH	PERMEABILITY
AJIDO	Low	High	Average
ARAROMI	Low	High	Average
BADAGRY	Low	High	High
EPE	Very Low	Very High	Low
GBELEJO	Very High	Moderately Low	Very High
OWORONSOKI	Average	Average	High

Source: Research data, 2013

Sieve Analysis: Using results obtained of the A.F.S Grain fineness number for all samples and when compared with table 1 for particle size and sieve analysis and table 2 for. relation between A.F.S grain fineness number and average grain size as suggested by Foseco Ferrous Foundryman's Handbook 2000. Then tables 7 and 8 show the expectation in terms of the grain size and grain size distribution effects on compactability, permeability and strength of all the six samples.

Ajido, Araromi and Badagry silica sands have wide range of grain size distribution broadening to fine side, narrow to the coarse side and high percentage of fine sand giving sand which could have low compactibility, high green strength and average permeability. But Badagry silica sand has a high percentage of medium fine sand which may result in higher permeability.

Epe and Oworonsoki silica sand both have very narrow range of grain size distribution to the coarse side and wide range broadening to fine side. Both sands show tendency of low compactability but due to a remarkable difference in grain size with Oworonsoki silica sand having lower percentage of fine sands than Epe silica sand, it is expected that Oworonsoki silica sand has an average green strength and high permeability while Epe silica sand will have a high green strength and low permeability.

Gbelejo silica sand shows a clearly different grain distribution and grain size from other silica sands. The sand has a wide size distribution to the coarse side and fairly narrow size distribution to the fine side. The highest percent grain size is medium thus giving sand with high compactability, average green strength and very high permeability. The values of A.F.S grain fineness number for all samples also confirm these assertions.

Table 7: A.F.S Grain fineness number versus Average grain size, Compactability, Strength and permeability.

	AJIDO	ARAROMI	BADAGRY	EPE	GBELEJO	OWORONSOKI
AFS GRAIN FINESS NUMBER	74.92	76.22	68.67	80.64	31.98	62.37
GRAIN SIZE RANGE (μm)	195-170	195-170	210-150	170-150	>395	220-210
AVERAGE GRAIN SIZE REMARK	Fine	Fine	Moderately fine	Very fine	Very coarse	Average
COMPACTABILITY	Low	Low	Moderately low	Very low	Very high	Average
GREEN STRENGTH	High	High	Moderately high	Very high	Very low	Average
PERMEABILITY	Average	Average	High	Low	Very high	High

Source: Research data, 2013

The higher the average AFS grain fineness number the lower the grain size and vice-versa.

Table 8: Summary of Grain size distribution

SILICA SAND TYPE	COMPACTABILITY	GREEN STRENGTH	PERMEABILITY
AJIDO	Low	High	Average
ARAROMI	Low	High	Average
BADAGRY	Low	High	High
EPE	Very Low	Very High	Low
GBELEJO	Very High	Moderately Low	Very High
OWORONSOKI	Average	Average	High

Source: Research data, 2013

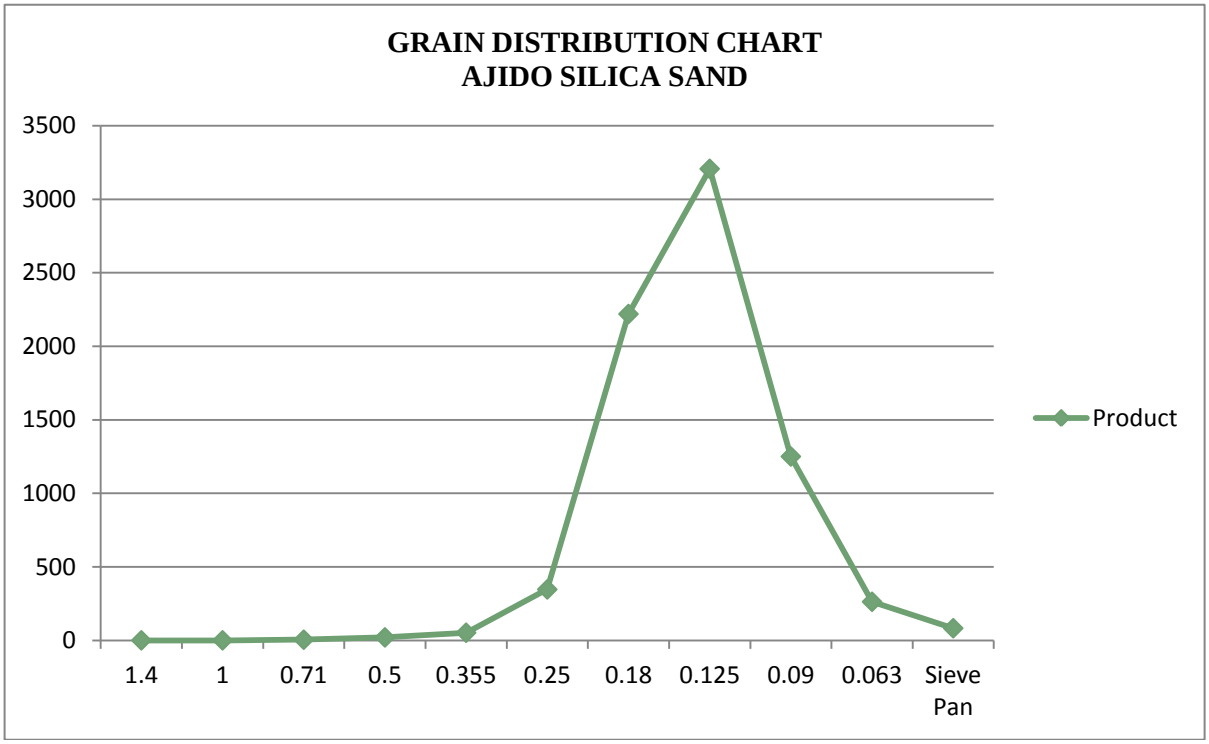

Figure 1a: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for Ajido silica sand

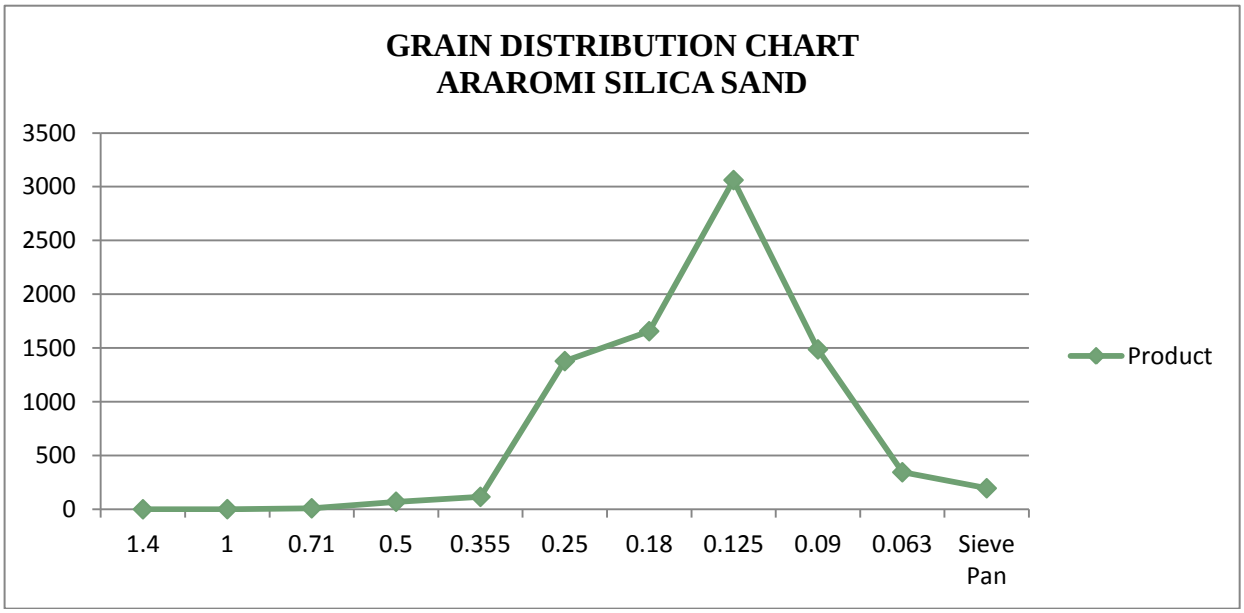

Figure 1b: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for Araromi silica sand

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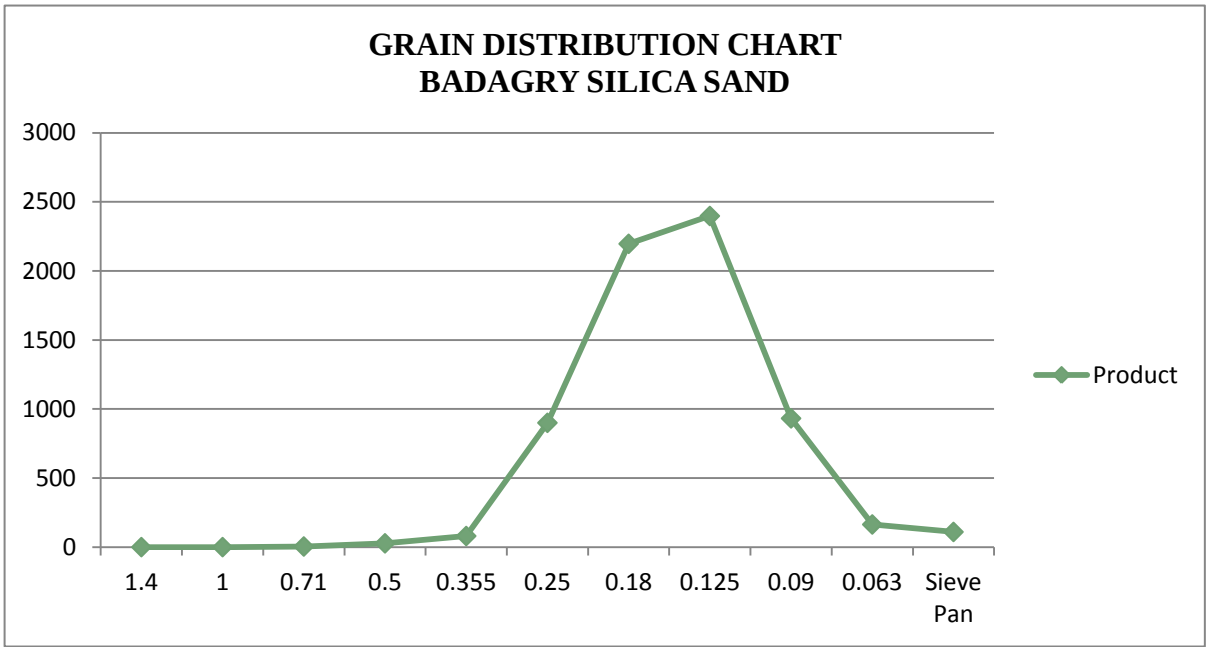

Figure 1c: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for Badagry silica sand

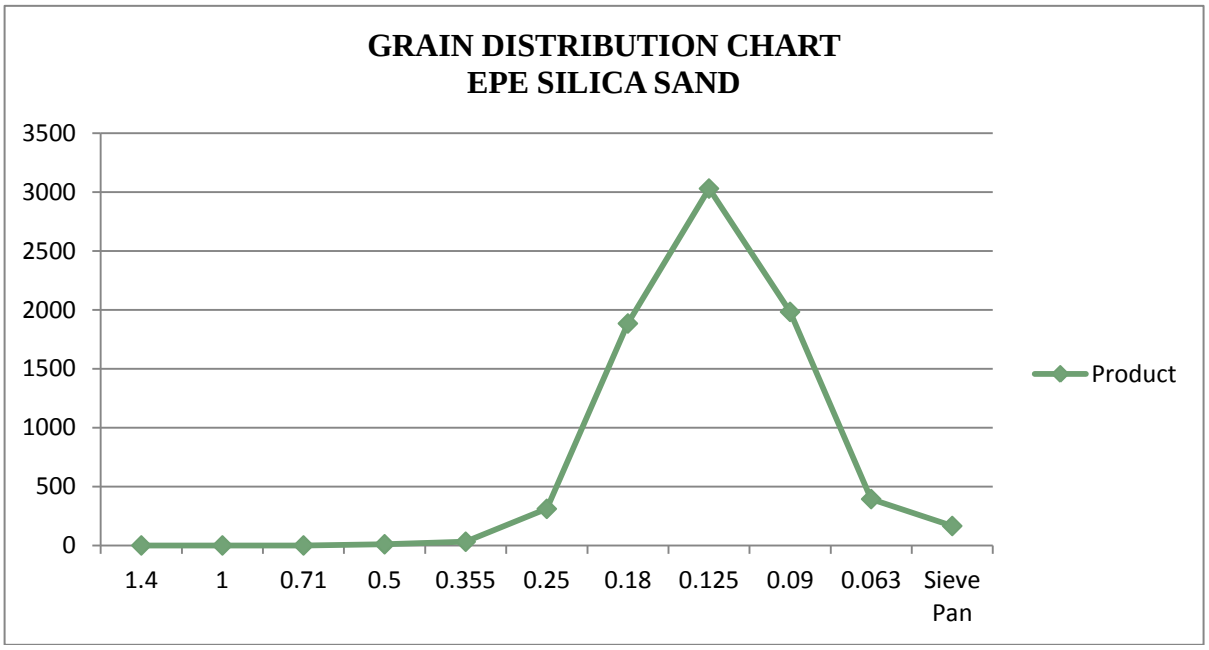

Figure 1d: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for Epe silica sand

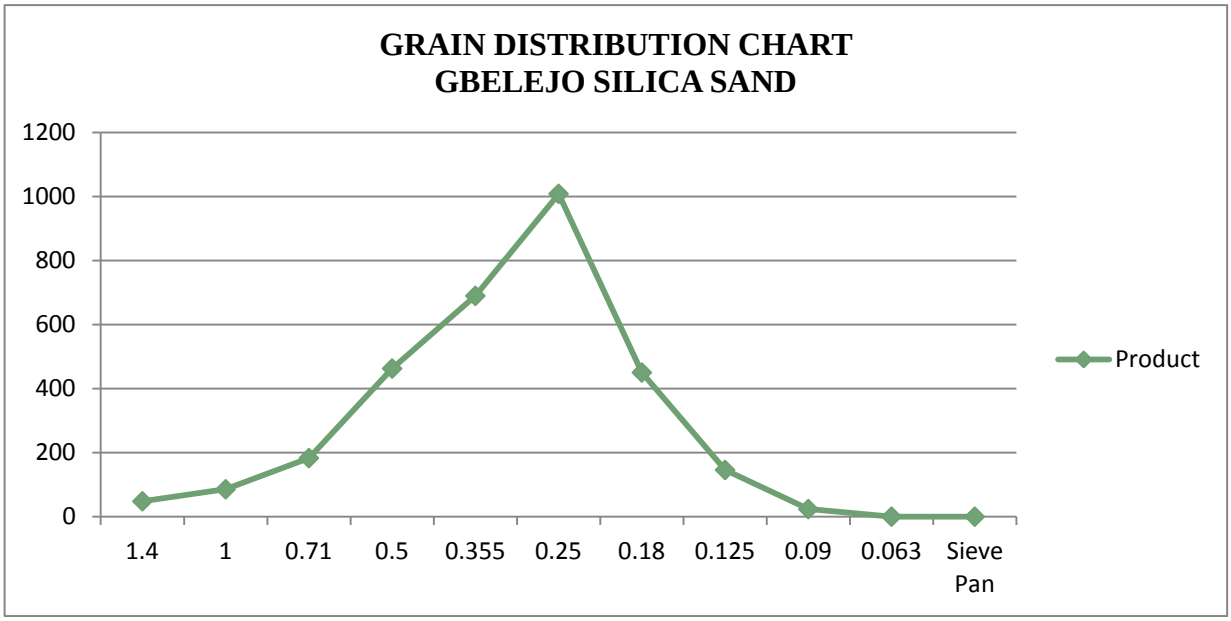

Figure 1e: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for Gbelejo silica sand

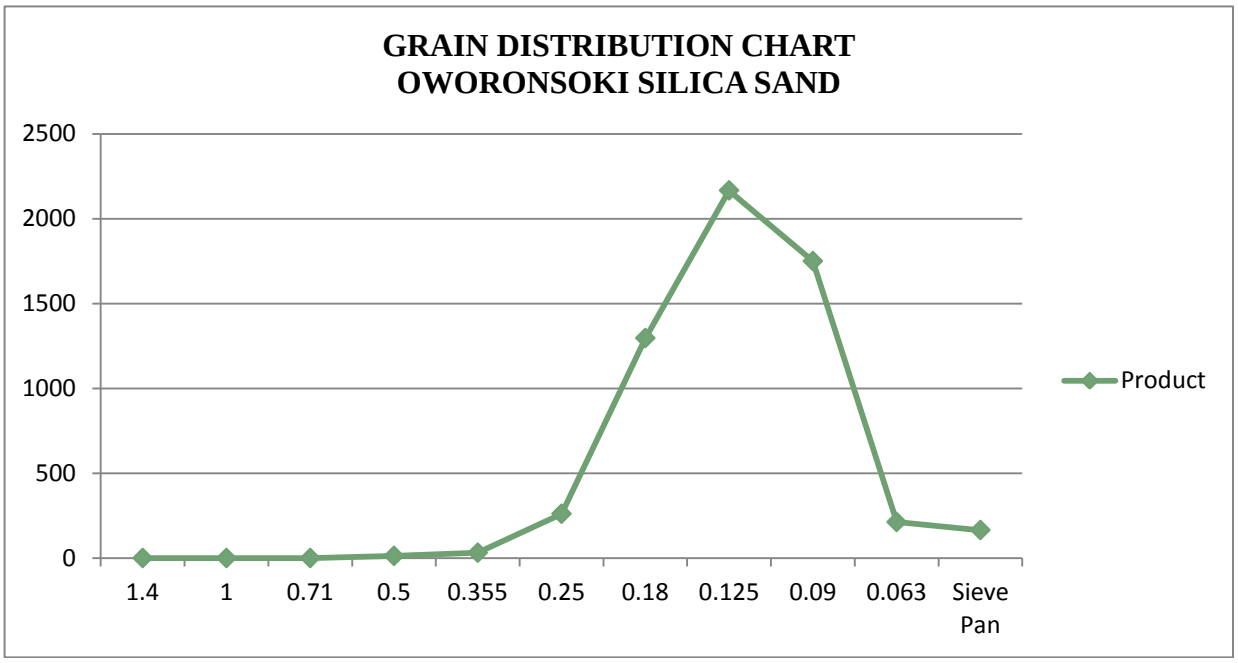

Figure 1f: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for Oworonsoki silica sand.

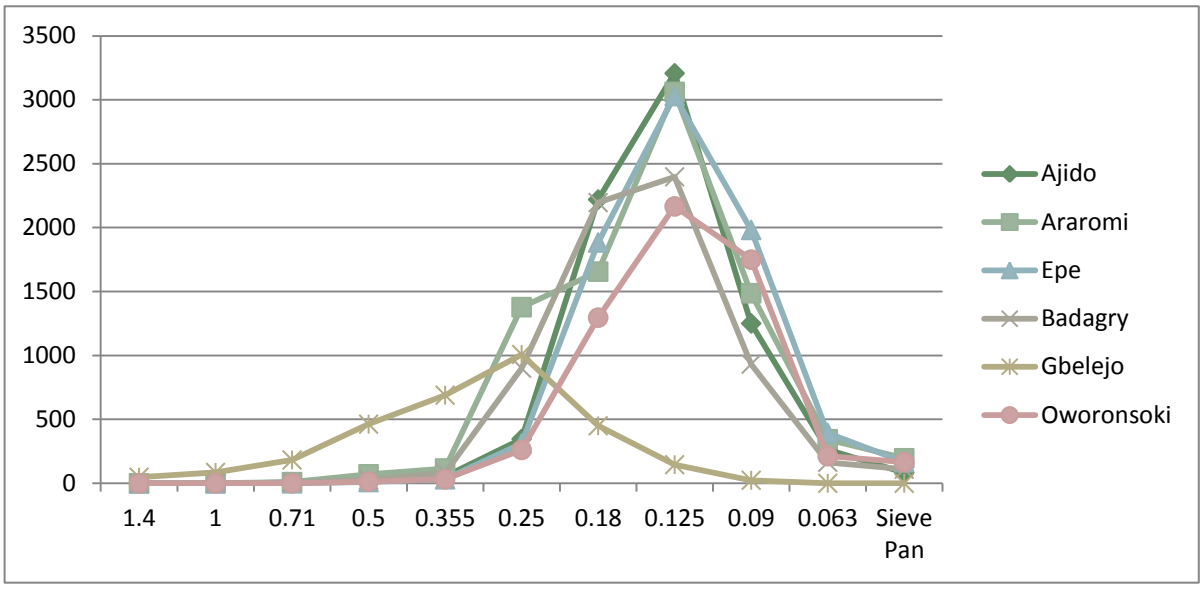

Figure 1g: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for all silica sand samples

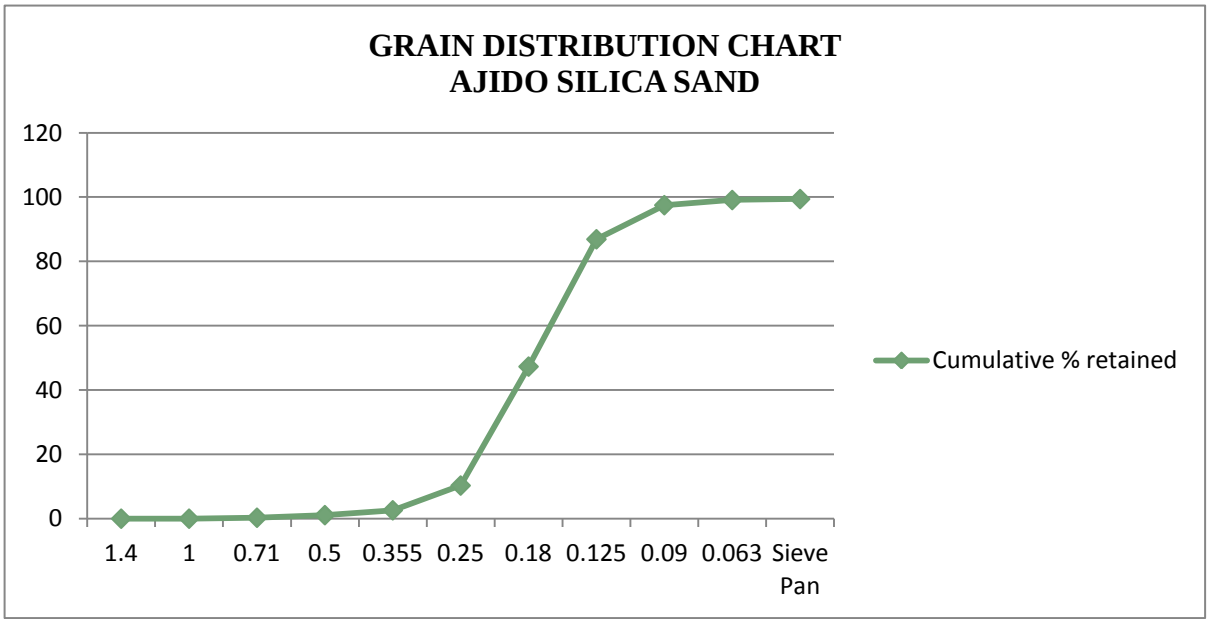

Figure 2a: Variation of mesh diameter in mm with cumulative % retained for Ajido silica sand

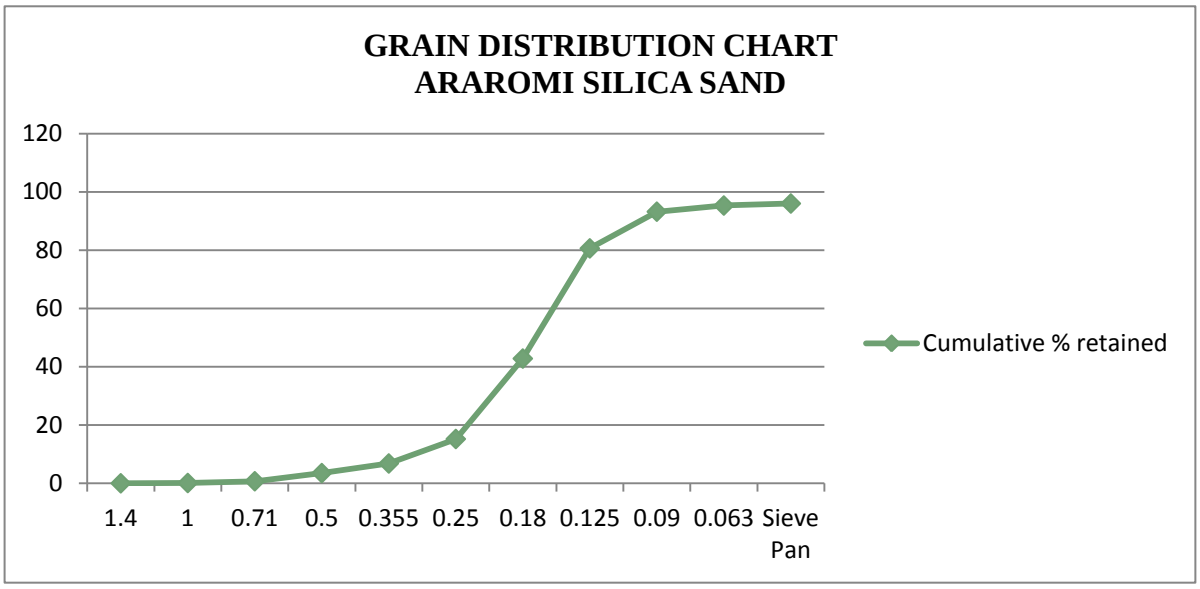

Figure 2b: Variation of mesh diameter in mm with cumulative % retained for Araromi silica sand

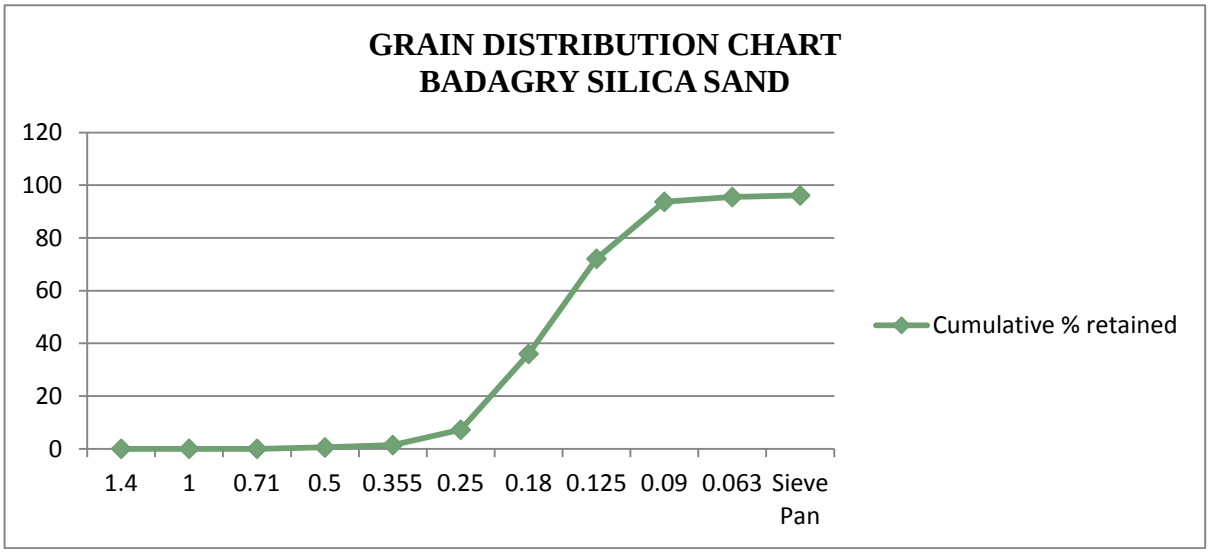

Figure 2c: Variation of mesh diameter in mm with cumulative % retained for Badagry silica sand

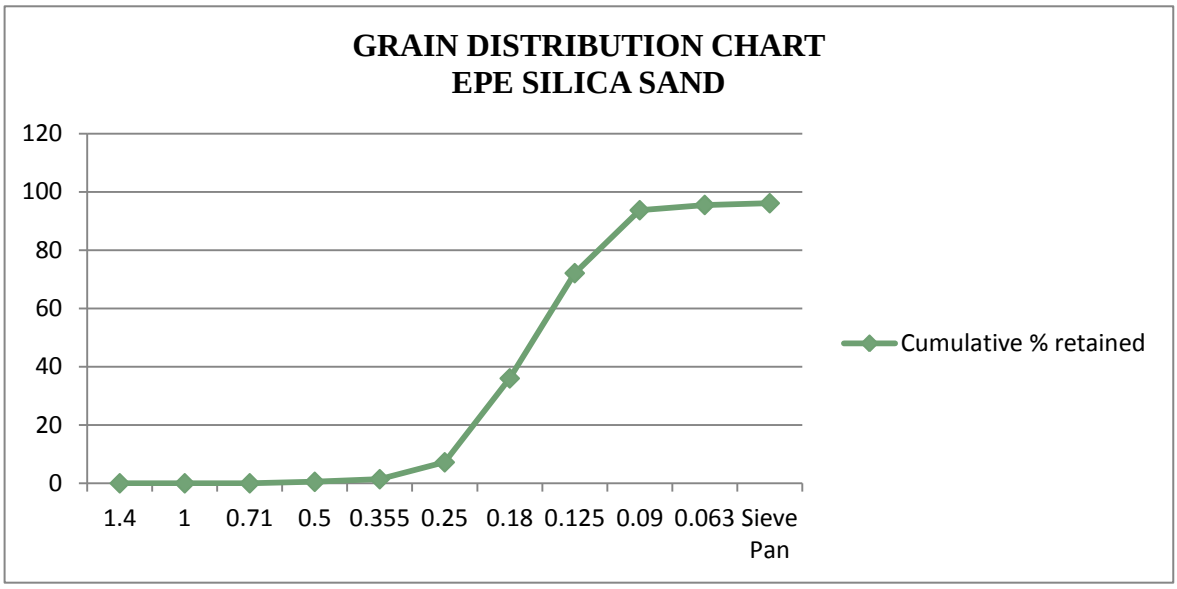

Figure 2d: Variation of mesh diameter in mm with cumulative % retained for Epe silica sand

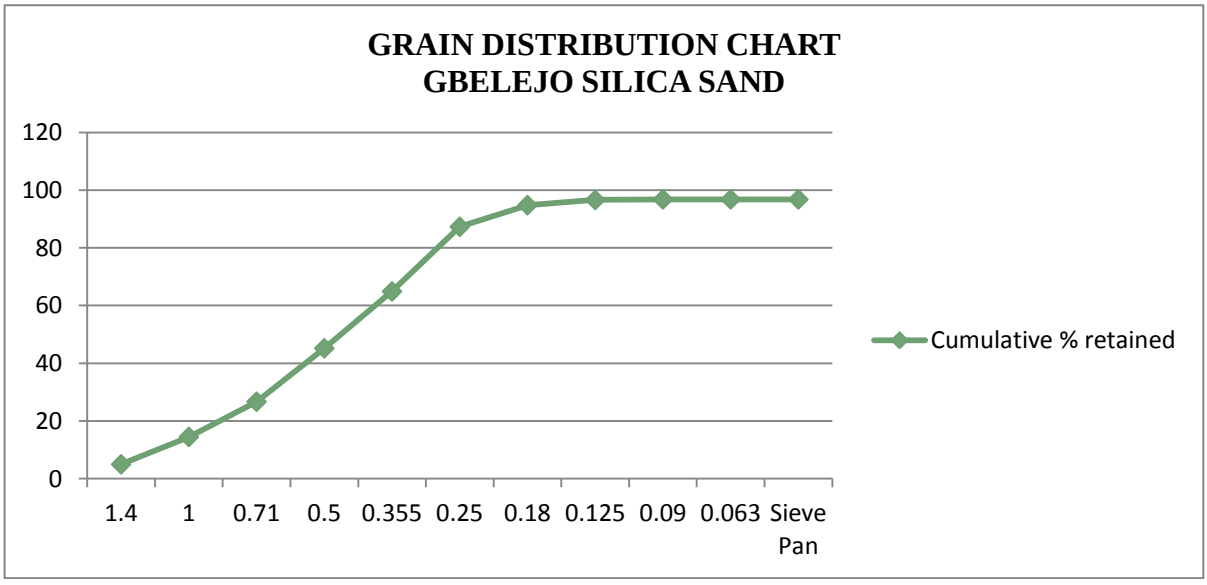

Figure 2e: Variation of mesh diameter in mm with cumulative % retained for Gbelejo silica sand

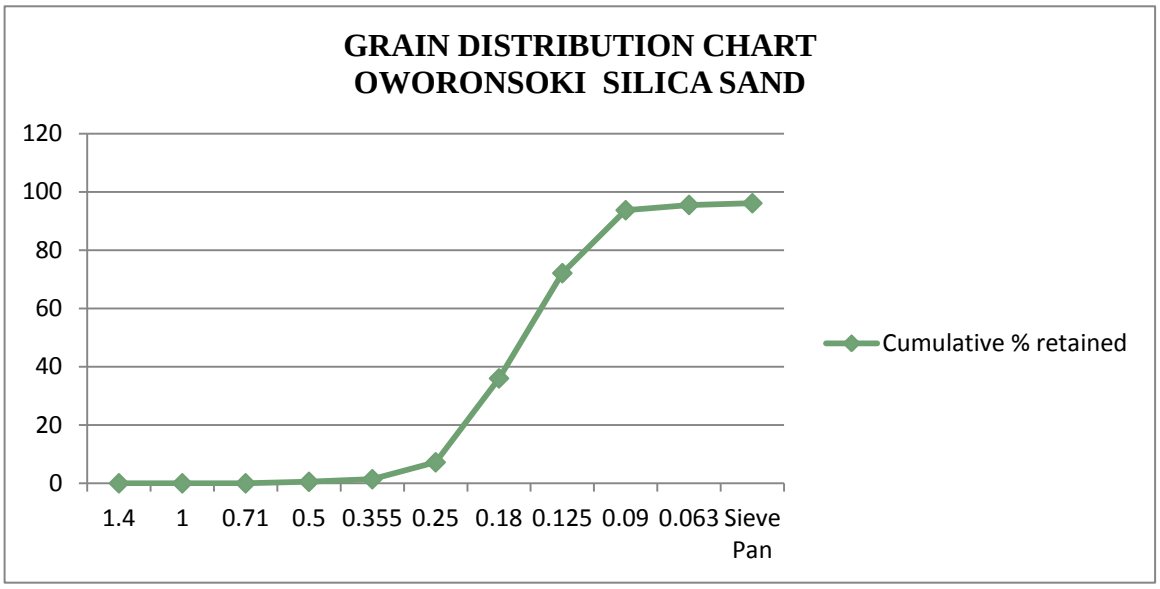

Figure 2f: Variation of mesh diameter in mm with cumulative % retained for Oworonsoki silica sand

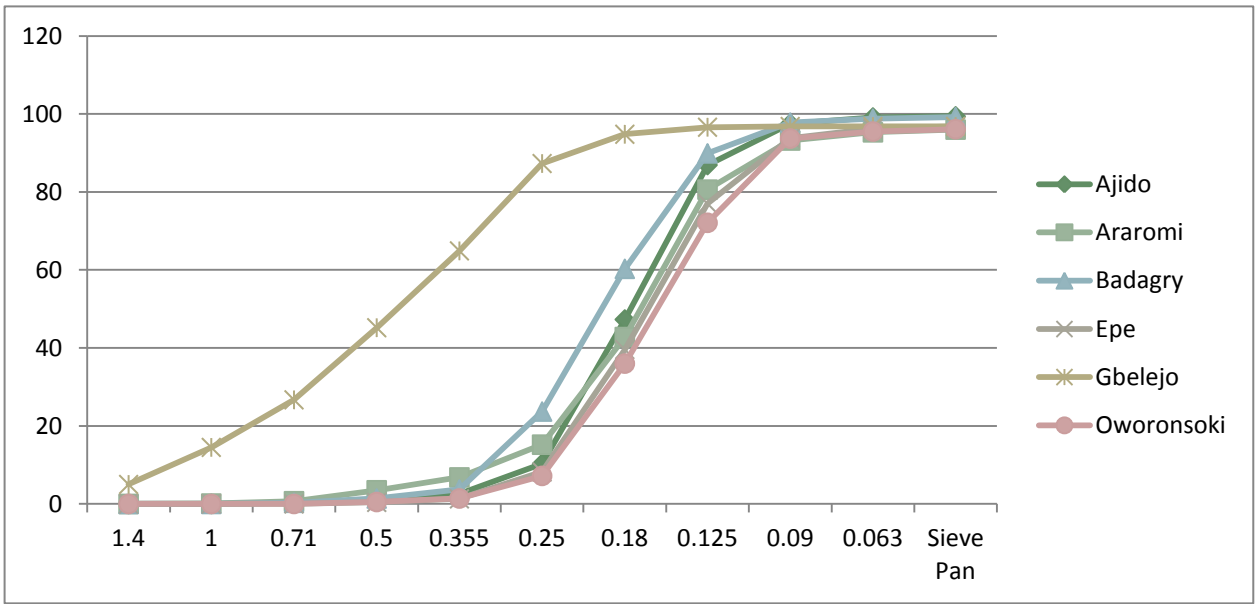

Figure 2g: Variation of mesh diameter in mm with cumulative % retained for all silica sand samples silica sand.

Conclusion

The study revealed that Gbelejo silica sand has the best compactability, green strength and permeability properties. The amount of active clay content of 0.6% and grain size distribution pattern makes its use suitable for both ferrous and non ferrous metals. Ajido, Araromi, Badagry, Epe and Oworonsoki silica sands all have compactablity, green strength and permeability properties which make their use suitable for casting non ferrous and ferrous metals, but with careful selection of binders, moisture content and size of casting if a sound casting is to be obtained.

However, this conclusion will be compared to results obtained in our further studies on determination of other properties like shatter index, permeability, moisture content, green strength and compactability on the same silica sand samples.

Acknowledgement

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Tracing Sources of Indigenous Knowledge on Building elements of Historic Structures: The Case of Bagamoyo Building Heritage Site in Tanzania

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Abstract

Indigenous people around historic structures exhibit diverse knowledge about building elements of historic structures. This diversity complicates preservation initiatives targeting indigenous as potential participants and experts. Identifying criteria which might be used in targeting could pave the best way to engage indigenous people in the conservation, preservation and enhancement of historic structures. This study traces the sources of indigenous knowledge on three building elements namely walls, binder and roof, using a multinomial regression model on 16 variables. The results suggest that knowledge on building elements can significantly be acquired through the learning process taking place over time. Full time occupations in fishing, heritage services or farming or any activities in a building heritage sites or temporary contact with heritage items does not offer an opportunity to acquire knowledge about building elements. That being the case unemployed people may be a prime target in a preservation strategy intending to utilise local knowledge about building elements of historic structures. Variables facilitating long term learning process such as age, formal education and residency in preserved building can be used to target potential participants in a preservation initiative. Gender based discrimination should be avoided as it has indeterminate though significant relationship with knowledge.

Keywords: Historic structure; Building Elements; Multinomial Logit Model, chi-square distribution

1.0 Introduction

Local meanings attached to historic sites may differ markedly from those of academics, national authorities, local communities and the tourism industry (Chatelard, 2010). Local communities value heritage goods because they are vested with certain knowledge base which is completely different from what other actors are aware of (English Heritage, 2008). This study assesses the stock of knowledge among indigenous population on three building elements that is Walling, Binder and Roofing materials. In this study therefore, the target population consists of local people living or working in a historic town of Bagamoyo. This was achieved through an intensive fieldwork involving interview, survey and physical observation of materials to confirm the authenticity of local knowledge. A multinomial logit model was then used to trace the sources of local knowledge on building elements. It is

evident that indigenous people's understanding of building elements varies considerably. While the majority have perfect knowledge on binder material, they have slight knowledge on walling material and have moderate knowledge on roofing material. This knowledge seems to have been acquired through the process of learning that has taken place over time rather than periodic visitation, participation or some other forms of temporal contact with historic structures.

People who are fully occupied in certain activities whether related to preservation or not, are most likely to have less knowledge about building elements than those who are unemployed. Similar participation in preservation initiatives in the past has not made participant more knowledgeable in terms of building elements when compared to non participants. That provides two reasons for failed preservation initiatives i.e. poor targeting by involving less knowledgeable individuals and incompetence among currently employed heritage managers limiting the chances for a successful preservation plan. Similarly proximity to historic structures has a limited chance of making a person more knowledgeable about building elements when compared to those who are completely outside Bagamoyo. This means knowledge may be acquired through visitation or formal education and interest about building elements.

1.2 Need for Local Knowledge in Preservation of Historic Structures

Building defects characterises most historic structures at the Bagamoyo building heritage site. These defects are generally considered as the main force behind reduced values; both economic and socio-cultural values (English heritage, 2006). An appropriate understanding of the extent and nature of building defects would result into carrying out appropriate repair works during conservation treatments. But such repair works cannot be undertaken efficiently without a clear understanding of the opportunity costs associated with maintaining those defects (Romero, 2004; Throsby, 2006). That is to what extend the society losses by neglecting or maintaining the status quo. Therefore an assessment intended to segment structural characteristics of historic buildings in relation to the level of knowledge and understanding of different actors is a panacea for a successful conservation operation. The stock of knowledge plus the flow of services and functions from historic buildings are the only items that can be manipulated to enhance the value of building heritage among visitors and local communities (Agnew & Demas, 2004; Harun, 2007; Rojas, 2007).

The planning and carrying out of renovations and the running of building heritage sites require skills and labour which call for traditional craftsmen (Liliequist, 2004). This requirement entails community involvement and networking, whereby stories associated with building heritage develop and reinforce norms (Allen Consulting Group, 2005). This results into the creation of a local knowledge base.

The decision to incorporate traditional craftsmen in any preservation initiative should be based on the local knowledge base rather than common practice. For example, where repairs are not possible, replacement of fabric/features calls for the use of local knowledge in identifying and locating similar materials existing today. If repairs to a timber frame (windows and doors) are recommended, for example, local knowledge can be used to identify new but like materials such as mangrove wood for the case of East African coastal buildings. Such knowledge can be used to estimate or assess whether repair is based on the same section and dimensions as the original materials used in a historic building. Using the wrong

material could result in damage and decay e.g. using cement mortars instead of lime for historic masonry can result in spalling and erosion, resulting into the need for expensive repairs. In a restoration plan indigenous people can provide their knowledge on the basic features of extinguished buildings.

1.2 Choice of Preservation Techniques

Experts' opinions play a crucial role in the process of designation and the determination of the supply of cultural goods, though their importance has diminished over time. Experts define the eligibility criteria to be an element of building heritage (what is being preserved) and establish the optimal combination between preservation and access (Mason, 2006 (a)). The experts' better information about the quality and values attached to the elements of cultural heritage means that market institutions including local experts is not necessarily a reliable institution to ensure the current and future provision of a cultural good (Ateca-Amestoy, 2011). However extensive reliance on expert opinions may often lead to undersupply of cultural heritage services and functions as observed in many building heritage sites in developing countries. The appropriate approach could be to elicit demand information from consumers and use them to support decision making regarding optimal provisional of cultural heritage. Therefore the preservation decision criteria could encompass two additional attributes of voluntary contributions and participatory management of building heritage.

1.3 Local Community Participation

There are three conventional ways to manage building heritage sites: privatization, state enforcement and international regulations (Zhang, 2010). All the three approaches neglect the most important mainstay-indigenous community (Mason, 2006 (a); Zhang, 2010). Heritage preservation must ensure that it obtains the participation of the majority in the society (English Heritage, 2008). A well-informed community, knowledgeable about the many dimensions of the value of their heritage will be more prone to appreciate existence and inheritance values, thus more interested in investing public and private resources in its preservation and development (Rojas, 2007; Chatelard, 2010). Even where heritage is the commons, its "tragedy" destiny is not utterly doomed, strong and cohesive relationship among communities make self-governing institutional arrangement possible and exceptionally important (Mason R. , 2006 (b)).

Understanding the extent to which local communities are knowledgeable about the value of historic structures entails a detailed analysis of both knowledge and preference for building heritage sites. One of the many ways of analysing building heritage sites is through structural analysis. Before embarking into the actual analysis one need to understand how much of the local knowledge can be taken aboard and who should be the target personnel during preservation initiatives. Therefore it is not only important to understand what knowledge is availability but also the sources of that knowledge so that appropriate targeting of participant can be done.

Defect analysis involves the collection and proper documentation of the affected building elements followed by appropriate laboratory analysis to determine the cause of failure. At an aggregate level most historic structures are made of a foundation, wall and in case of buildings a roof. Therefore an assessment of the local knowledge based on these items is

essential before undertaking any laboratory experiments. Local communities can help experts in identifying potential historic elements which may further be subjected to scientific investigation and facilitate the whole process of preservation.

Local knowledge on the three building elements of interest in this study may be shaped by a number of factors. People with extensive experience in preservation can be expected to be more knowledgeable than those who have never been in touch with historic structures (Mason R. , 2006 (b)). The more the experience the more the knowledge derived from cultural heritage consumption. Likewise people with experience in preservation or activities relating to heritage management are likely to attach a higher value than those without. Formal education also plays a crucial role in the understanding of historic structures. Most of the inbuilt values of cultural heritage can be known through formal education (Ateca-Amestoy, 2011). Likewise visitation to building heritage site may enhance knowledge on building elements. However visitation provides only partial learning since it is motivated by aesthetic expectations and, growingly, environmental concerns and national pride (Chatelard, 2010). Thus visitation to preserved sites may not provide an opportunity to learn extensively the structural characteristics of historic structures.

Empirically demographic variables can also be included when making an assessment of local knowledge on building elements. Variables such as gender and age are often included because policy makers are often interested with the redistribution effect of any policy decision (Ateca-Amestoy, 2011). However it is not so obvious on whether male and female value heritage differently, though certain building heritage values such as attraction are more likely to be favoured by female than males. The older a person becomes the more experience they have in building heritage hence the more knowledgeable they boast about historic buildings.

Older people may be knowledgeable about building elements rather than younger people because they are more interested with details rather than view. The younger people may lack the structural details while attaching a higher value on attraction and beauty.

Rojas (2007) argue that a community that barely knows about cultural heritage values is more inclined to accept its destruction to make room for new buildings. These problems are at the core of the difficulties experienced by most communities in mobilizing financial, institutional and human resources towards the sustained conservation and development of urban heritage (Figure 1). The difficulty lies in the lack of clear links between the social processes through which building heritage is valued with the social processes through which financial and institutional resources are allocated (Rojas, 2007; Buelens, 1992). Forging a link between end-users and decision-makers is fundamental to ensuring that cultural heritage remains relevant and reflects the lives of communities (Cassar, 2006; Association of Independent Meseums, 2010).

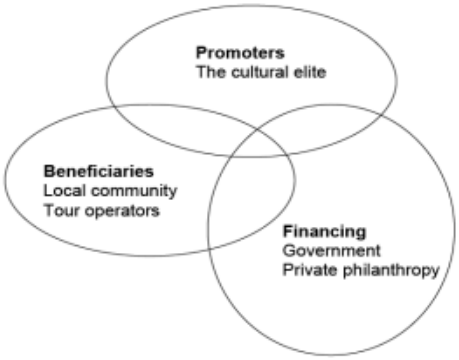

Figure 1: Cooperation among Stakeholders for sustainable heritage preservation (Rojas, 2007)

The key to building heritage sustainability lies in better alignment of the actors so as to ensure that those that benefit from urban heritage preservation and development coincide to the greatest extent possible with those that pay for the required interventions and with those that promote the process (Rojas, 2007). There should be greater public access and end-user involvement in cultural heritage decision-making; achieving this is fundamental to ensuring that building heritage remains relevant and reflects the lives of communities (Cassar, 2006; Allen Consulting Group, 2005). This involves realigning the interests of all the social factors involved in the process and allowing for different social resource allocation processes to work harmoniously towards a common goal. Better urban heritage research and education is necessary condition, but is not sufficient. Institutional reforms and adequate signals to the markets must also be instituted (Rojas, 2007).

1.4 Mode of Financing Preservation of Building Heritage Sites

When cultural heritage goods are viewed as merit goods, there is no way through which an adequate or satisfactory amount could be provided except through public funding. Mazzanti, (2002) provides that merit good policies should be financed out of general taxes regardless of the expression of actual preferences, implying a general redistribution of resources. For all merit goods no relationship should be maintained between the individual benefit and the merit good benefit. Contrary to that there are situations where one may need to capture economic surplus as expressed by actual users of cultural goods in order to instantiate financial flows. In this case economic instruments and institutional mechanism including charging policies and voluntary contributions may be evoked to make redistribution of resources operational and effective (Rojas, 2007).

Apart from market and public funding approaches to the provisional of building heritage services and function, altruism offers additional approaches towards conservation and preservation. Individual tax payments and voluntary contributions reflect people's short and long run economic preferences, in form of willingness to pay (Mazzanti M. , 2003). This is often the case when redistribution of the flow of services and functions from building heritage is sought. In this case voluntary contributions can be an effective means to ensure sustainable provision of cultural heritage for actual and potential users, by means of infra- and inter-generational financial flows (Mazzanti M. , 2002).

1.5 Background to Bagamoyo Building Heritage Site

Bagamoyo is a small historical town, which is approximately 70 kms, North of Dar es Salaam along the splendid sandy beach, curved palm, and winged with the unpolluted water of the Indian Ocean. It is located on the Zanzibar Channel, just opposite the Island of Zanzibar. It is the second largest district of Coast region on the Eastern part of Tanzania mainland. The district covers an area of 9,842km^2 which is 29.3% of the total surface area of Coast region. The district has 6 division, 16 wards and 82 subwards/mitaa (including villages in rural areas) (United Republic of Tanzania, 2007).

The word "Bagamoyo" originates from the Kiswahili word "Bwagamoyo" which is conceived to mean "throw down your heart" which is linked to caravan porters who praised the town which is today known as Bagamoyo. The word is also linked to slaves lamenting "crush down your heart" reflecting the desperation and despair of the 'broken hearted' captives of the 18thC whose voyage into the unknown began at this historic town (Elin, 2006). Today Bagamoyo is still a home to many people including descendants of captives who were rescued by missionaries at the climax of the barbarous slave trade in the 18th C. It is one of the most fascinating towns in East Africa, with a host of historical associations. The relation to Zanzibar was very strong in history, because most of the slave trade, ivory trade and expeditions of traders and explorers from and into the interior of East Africa were organised through Bagamoyo.

For decades up to the end of the 19th century Bagamoyo was the main terminus in the east African – Arab and Indian trade network (Hamisi, 2010). Oman Arabs were the first immigrants to resettle in this small coastal town of the 17thC. Their wish was to attract more commerce to Bagamoyo and they were very successful. A large number of Oman Arabs and Indian merchants settled in Bagamoyo and established Bagamoyo as a trade center on Africa's East Coast. Arabs and Indian were businessmen while African population worked at the plantations and salt mines or as fishermen. Many different African tribes came to Bagamoyo because of the caravans. Its closeness as a mainland port close to Zanzibar led to its development as a centre for caravan and an expansion of commerce in ivory and slave trade (Watson, 1982). This proximity also attracted traders from Arabia (mostly Yemen), the Persian Gulf region of Iran (especially Siraz), and west India. Boat building center that supplied craft to other coastal settlements was also built at this town. Prior to the caravan time the trade consisted mainly of dried fish, gum, copra and salt. This merchandise laid the foundation to the town's wealth. Immigration to Bagamoyo was not only triggered by its prosperity but also by the town's resistance to famine, which made it a haven in times of troubles in the interior.

The slave trade era town of Bagamoyo is graced with a lot of valuable narrations about the town. One may observe historical narrations in terms of songs and buildings used as slave centres still existing today. The caravan entered the port of Bagamoyo on central trade route, coming from the Great Lake Tanganyika and Victoria, whereas porters carried ivory to Bagamoyo. Most of the slaves saw the Indian Ocean for the first time in their lives at Bagamoyo with the majority having died on the way. At its peak around 1880 an estimated 50,000 slaves per year were taken from the interior to Bagamoyo for shipment to the slave markets and spice and clove plantations of Zanzibar. During this same period Catholic missionaries ransomed as many slaves as possible and settled them for their protection in the

"Christian Freedom Village" in Bagamoyo (Elin, 2006). Therefore by the 19th C, two different societies existed in the town at the same time; the slave based societies and the societies of free people on the Catholic compound.

Today Bagamoyo is still a place of considerable significance to world history, both as an entry point for Arabs and European missionaries, explorer and traders in east and central Africa and in the history of the slave trade. Bagamoyo boasts as one of the East Africa's largest assembly of 18th century architecture. It was at one time the most important city of mainland Tanganyika and the most important harbour in East Africa. When the colony of German East Africa was established in 1888, Bagamoyo was chosen as the capital (Watson, 1982; Elin, 2006). However, over time the importance of Bagamoyo has declined due to both historical and economic reasons (Hamisi, 2010). To the end of the 19th C and throughout the 19th C Bagamoyo prominence has significantly deteriorated to the verge of collapse. The town of Bagamoyo is a home to many spacious and beautiful historic buildings dating back to the early contacts between East Africa, the Middle and Far East. These buildings remind the local communities and the world of the ancient old city state encompassing tremendous skills, and intellectual creativity worthy of preservation in the modern world.

Based on the 2002 national census, the district of Bagamoyo had a population of 228,967 which is 25.8% of the Coast region's population i.e. 885,017. Of all the Cost region's districts, Bagamoyo experiences the highest population growth of about 31.7% based on 1988 and 2002 census and projections for 2005 (United Republic of Tanzania, 2007). This study covers mainly two wards in central Bagamoyo that is Dunda and Magomeni since our interest was to extract knowledge about historic buildings. These two wards comprise most buildings especially Dunda ward which is a home to the commonly known "Bagamoyo Stone Town". A study sample comprising the majority of respondents from Dunda and Magomeni ward sufficed to meet that goal. However some information was collected in Zinga ward and from some respondents who had no permanent residency within Bagamoyo in order to extract a more generalised information platform for prospective research in the area in the future.

2.0 Research Methodology

The data presented in this paper were collected using a survey designed in such a way as to allow respondents to express their own understanding of the materials used in historic buildings. The questions were open ended revolving around three building elements i.e. mortar, roof and wall. Thereafter the responses were classified on a five level "categorical" scale based on interpretative approach. Although the interpretative codes in Table 1, seem to be on a "Likert" scale, the meanings attached to them are so different to reflect a continuum of the same phenomenon. The responses were analysed based on the knowledge and understanding derived by the researchers on the responses given by the respondents. This process is summarised in Table 1. It should be noted that the surveyor was responsible for confirming the classification of responses during data collection.

Table 1: Codification of Survey Responses

S/N	Interpretative Code	Responses		
		Roof	**Wall**	**Binder**
0	Completely	Do not Know,	Do not know,	Cement, Stones, mud

	Unknowledgeable	Concrete	Wood, Burnt bricks	
1	Slightly Knowledgeable	Stones, Matumbawe (coral stones), limestone	Stones, stones and limestone	Raw sugar, coral stones, mud and raw sugar
2	Moderately Knowledgeable	Wood, Wood and Stones	Ocean sand, stones and mud	Raw sugar and limestone, limestone and sand
3	Highly Knowledgeable	Coral stones & wood, Corrugated Iron Sheet, iron Sheets & wood	Coral,	Lime, Limestone and Mud, Mud or Limestone
4	Perfectly Knowledgeable	Mangrove wood, (Mikoko), coral stones & corrugated iron	Coral stones, Limestone	Coral stones powder, limestone powder

Apart from that, the survey intended to incorporate people living in both urban and rural Bagamoyo. Therefore no specific sample size was determined rather researchers had to find respondents in their workplaces and residents in which case any person could be targeted. The main purpose was to extract as much information as possible in order to derive their understanding of Bagamoyo historic buildings in terms of structural elements and their willingness to provide material support in the preservation of the site. This analysis was interpretative and relied on quantification of responses through cross-tabulations automated in SPSS.

In tracing the sources of knowledge among indigenous population, a multinomial logistic model (MNL) was implemented in SPSS. A multinomial logistic model can be used to model unordered categorical response variables. The approach is to compare a number of dichotomies where the output comprises a number of logistic regression models that make specific comparisons of the response categories. When there are j categories of the response variable, the model consists of j-1 logit equations which are fit simultaneously. Thus a multinomial logistic regression fits multiple logistic regressions on a multi-category unordered response variable that has been dummy coded.

In this study the choices are based on five knowledge levels (j=5) and three building elements of interest i.e. walling, binder and roofing materials (i=3) each category of knowledge is attached to a certain building element being studied. Thus 4*3 multinomial logistic regression models are estimated. The regressions model the relationship between knowledge levels on building elements of historic structures with 16 variables. For each building element, the knowledge levels are compared with a reference category variable of "Completely Unknowledgeable".

The model of choice behaviour between the five knowledge levels (j=5) is represented using 12 (i.e., j -1) logit models taking a general form shown in equation 1.

$$\log \frac{\Pr(\text{Knowledge level (ji)})}{\Pr(\text{Completely unknowledge})} = \alpha + \beta_1 \text{EDUC} + \beta_2 \text{AGE} + \beta_3 \text{RESP(1)} + \beta_4 \text{SEX(1)} +$$
$$\beta_5 \text{OCBHS} + \beta_6 \text{OCOCW} + \beta_7 \text{OCBUS} + \beta_8 \text{OCFIS} +$$
$$\beta_9 \text{OCPES} + \beta_{10} \text{RDUNDA} + \beta_{11} \text{RMAGO} +$$
$$\beta_{12} \text{RWARD(O)} + \beta_{13} \text{WPR(1)} + \beta_{14} \text{PRP(1)} +$$
$$\beta_{15} \text{PVISIT} + \beta_{16} \text{PEXP} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where "Completely unknowledgeable" is the reference knowledge level.

The definition of variables used in equation 1 is provided in Table 2. In the model provided in equation 1, the effect of individual or groups of explanatory variables on the response is assessed by comparing the deviance statistics (-2LL) for two nested models (see Equation 1). The resulting statistic is tested for significance using the chi-square distribution with the number of degrees-of-freedom equal to the difference in the number of terms between the two models (see equation 2).

$$-2LL_{diff} = (-2LL_p) - (-2LL_{p+q}) \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where p is the smaller nested model, and p+q is the larger model.

This model fit statistics is estimated automatically together with the multinomial regression results in SPSS. The statistic accompanies each explanatory variable and measures the change in deviances (-2LL) that occurs when each of the explanatory variables are removed from the full model. The significance of each coefficient of the explanatory is assessed at 5% significance level where a sigma value less than or equal to 0.05 is considered significant, otherwise the variable under consideration is not significant.

The use of a multinomial logistic regression results from the fact that the knowledge levels were attached with a meaning other than ordering. The order with which knowledge levels are categorised is not what matters rather the meaning associated with them. Therefore the levels are considered as unordered categorical variables. The data used in this study were collected in a multi-attribute choice experiment. However given the fact that each of the responses can be linked to a similar number of respondents, this does not have an effect on the final results.

Table 2: Definition of variables

S/N	Variable Code	Variable name	Values
1	EDUC	Level of education	Numerical continuous
2	AGE	Age	Numerical continuous
3	RESP	Residency in a Preserved Building	Dummy;1=Yes
4	SEX	Sex	Dummy; 1=Male
5	OCBHS	Occupation in Building	Categorical: 1 =Building Heritage

		Heritage Services	Services
6	OCOCW	Occupation in Other Conservation Work	Categorical; 2=Other Conservation Work
7	OCBUS	Occupation in Business	Categorical; 3=Business
8	OCFISH	Occupation in Fishing	Categorical; 4=Fishing
9	OCPES	Occupation in Peasantry	Categorical; 5= Peasant
10	RDUNDA	Residency in Dunda ward	Categorical
11	RMAGO	Residency in Magomeni ward	Categorical
12	RWARD(O)	Residency in other wards	Categorical
13	WPR	Work in Preserved |Building	Dummy; 1=Yes
14	PRP	Preservation Participant	Dummy; 1=Yes
15	PVISIT	Preserved Site Visitation	Dummy; 1=Yes
16	PEXP	Preservation Experienced	Dummy; 1=Yes

3.0 Data Analysis and Results

In this paper historic structure comprises existing buildings, ruins and other monuments such as old graves. Thus the focus is not on individual buildings rather the heritage site as a whole. Based on this study paradigm it was necessary to allow peoples as an object of study to define the dimension of our study. Thus the term Bagamoyo Building Heritage Site is strictly used in the sense attached by respondents on building they considered "most known" to them. The number of building and structure that are under active preservation far exceeds what were identified as most known buildings. However since structures of historic structures comprise basically the same building elements, it can still be urged that what is discussed in this paper may be relevant for the Bagamoyo heritage site as a whole.

3.1 Study Sample and Characteristics

As noted above the term Bagamoyo Building Heritage Site was compounded to encompass those buildings and structures identified by respondents as being the "most known" to them. Hence all responses and data in this paper are strictly confined to these buildings and structures which are summarised in Table 3. It can be observed in Table 3 that most respondents (53%) believe that the Bagamoyo historic buildings are in good condition despite the researcher's observation and ultimate evaluation that the buildings and other structures are extremely damaged some of them to a state of disrepair. Also it should be noted that Table 2 shows that substantial number of respondents (33%) were of the view that the buildings are in poor condition.

Table 3: Most Known Buildings within Bagamoyo Building Heritage and their Condition

S/N	Most Known Building	Perceived Building Condition			Total	% Ranking of Good	% Ranking of Poor
		Good	Moderate	Poor			
1	Caravan Serai	112	2	45	**159**	10	9
2	Old Fort	91	7	53	**151**	4	12

3	Old Boma	31	3	18	**52**		2
4	Old Market	25	0	9	**34**	11	7
5	Customs House	18	1	14	**33**		1
6	Kaole Ruins	16	0	12	**28**	13	5
7	Arab Tea House	13	2	8	**23**	9	6
8	Missionary Church	16	0	3	**19**	2	15
9	Liku House	12	0	4	**16**	14	3
10	Old Postal Office	9	2	4	**15**	1	16
11	Mwambao Primary School	8	0	4	**12**	12	4
12	Mantepu	1	0	5	**6**	5	11
13	German Cemetery	1	1	2	**4**	8	10
14	Missionary Cross	1	0	1	**2**	6	8
15	Catholic Museum	0	0	1	**1**	3	14
16	Dunda Observation Post	0	0	1	**1**	7	13
17	Shites Mosque	1	0	0	**1**	15	
	Total	**355**	**18**	**184**	**557**		

Comparatively the buildings were ranked in terms of the percentage of respondents who gave their opinion on the building condition as being either Good or Poor. In the list of top 5 buildings which are considered to be in good condition we have; Old Postal Office (1), The Missionary Church (2), The Catholic Museum (3), The old Fort (4) and Mantepu (5). On the list of top 5 buildings considered to be in Poor condition we have; Customs House (1), Old Boma (2), Liku House (3), Mwambao Primary School (4) and Kaole Ruins (5). It should be noted that the Old Boma has been under a "stalled" rehabilitation for a couple of years now.

The consistency of the ranking was assessed based on the correlation coefficient (R^2). The results are displayed in Figure 2. It can be observed that the correlation is significant at R^2= -86.43%. This can be interpreted as the ability of a respondent to consistently identify building conditions which are good against those that are poor. Therefore a respondents identifying a most known building as good has about 86.43% less chance of identifying the same building as being in poor condition.

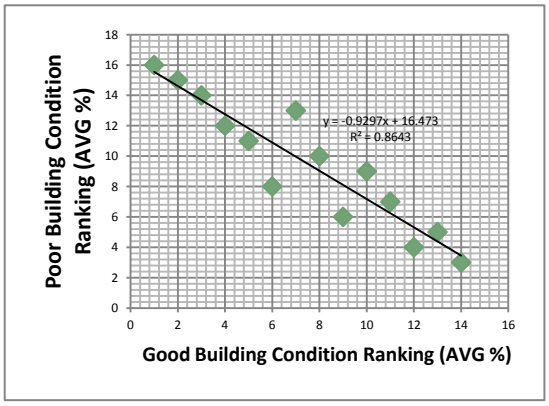

Figure 2: Consistency of responses on building condition

Table 4 provide additional information about the demographic characteristics of respondents. It can be observed that most of the responses were collected in two wards of Dunda and Magomeni despite lack of an initial focus in those wards. Therefore the concentrations of responses within few wards were a result of coincidence rather than intention. The target was Bagamoyo communities but because of financial constraints the research team could not travel far beyond the urban wards leading to the kind of sample presented. These shortcomings are not expected to significantly elude the conclusion reached in favour of biasness since most respondents' fall within the social economic spectrum of the people of Bagamoyo hence still represents the intended population.

Table 2 further displays that the total number of people who responded to the questionnaire were 557, however because some of them had a lot of incomplete information, the responses were filtered as to remain with only 386 usable responses. In Table 4, it can be observed that the majority of the respondents were from Magomeni ward and Dunda ward with the remaining 14 wards having only 8 respondents. The survey also encountered about 22 people from outside Bagamoyo.

Table 4: Demographic Characteristics of the Sample

		Ward of Residency				**Total**
Gender	**Age Group (in Years)**	**Dunda**	**Magomeni**	**Others**	**Outside**	
Female	Between 12-18	0	4	0	0	4
	Between 18 - 25	6	12	0	3	21
	Between 25-35	23	31	2	6	62
	Between 35-50	19	20	2	3	44
	Above 50	2	7	0	1	10
	Total Female	**50**	**74**	**4**	**13**	**141**
Male	12 and Below	1	0	0	0	1

	Between 12-18	5	7	0	1	13
	Between 18 - 25	26	28	2	2	58
	Between 25-35	45	57	1	4	107
	Between 35-50	28	31	1	1	61
	Above 50	2	2	0	1	5
	Total Male	**107**	**125**	**4**	**9**	**245**
	Grand Total	**157**	**199**	**8**	**22**	**386**

In terms of gender it can be observed in Table 4 that the majority of the respondents were males making about 63% of the total number of respondents. For both females and males, the majority of the responses came from people aged between 25 -35 years of age. The least numbers of responses came from those aged between 12-18.

The survey also encountered one male person aged below 12 years of age. For older people the survey encountered few older people basically because they are few in the society and in most cases they are not found in workplaces which were the main focus of this survey. Comparatively older female respondents were encountered frequently than their counterpart males.

3.2 Potential Community Engagement in Preserving Historic Building Heritage

Potential Personal Contributions (PPC) entails individuals chosen work or activity which relate to the preservation of Bagamoyo historic buildings. These contributions are compared with income classes across the gender dimension. This test helps in the understanding of the kind of contributions local communities can make in preservation of historic buildings. It also assesses whether such contributions relate to ability in case of financial obligations. It is observed from the analysis that the majority of respondents were interested in providing manual labour (43%) and about 40% of respondents were interested in providing nothing. The remaining 17% were interested in the following activities: provision of cultural services (3%), management (about 14%) and other cross cutting activities involving one or more of the above (1%).

The PPC was linked to income groups of respondents as shown in Figure 3. It can be observed that the majority of the respondents who can potentially contribute manual labour have incomes of or below TZS 300,000/=. Those with incomes between TZS 100,000-300,000/= predominates in the management and cultural services contributions. Those with incomes above TZS 700,000/= prefers contributing nothing though they also dominate other income groups in other forms of contribution. The responses in the analysis further shows that the majority of males (42%) are interested in providing nothing for building heritage which account to 75% of all respondents not interested in contributing for building heritage preservation. It is also evident that the majority of those males fall in the lower bounds of the income ladder. The majority of females (49%) are interested in providing manual labour and

the incomes of the majority of these women also falls within the lower bounds of the income ladder.

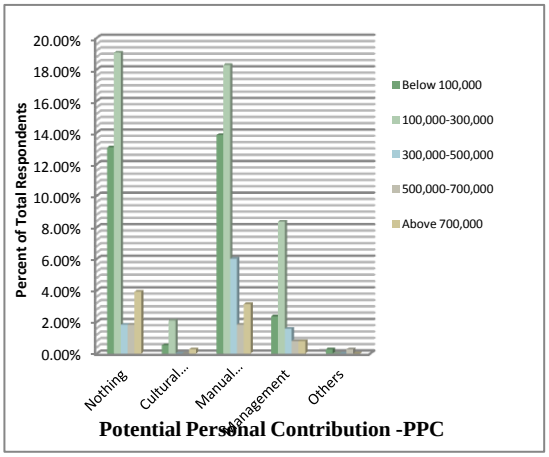

Figure 3: Potential Personal Contribution across income groups

These responses give an indication that income might not be a good explanation for failure to participate in the preservation of historic building. Females' accounts for the majority (22 out of 31) of the respondents with the highest income but unfortunately the majority of these women (50%) are interested in contributing nothing in heritage preservation. Likewise contributions within the identified activities concentrate within nothing, manual labour and management activities within these PPC responses from those with income less than TZS 100,000/=

3.4 Knowledge on Building Elements of Bagamoyo Historic Structures

To understand variation in perceived building condition, it was necessary to examine knowledge of construction elements and weaknesses as identified by local communities. We used three structural components i.e. Binder (Mortar), Walling Material (Bricks) and Roofing material to examine how the local community in Bagamoyo understand historic masonry structures. These structural components were linked to knowledge on design of historic buildings as a control variable.

The results of the analysis show that most respondents know the designs of the building or structure under consideration as in all the three clusters presented most respondents fall in the Yes category rather than the No in terms of building design. However in terms of knowledge about roofing materials most respondents (43%) have moderate knowledge while about 25% have perfect knowledge. In terms of walling material the data show that about 71% of respondents have slight knowledge about walling material while about 23% have perfect knowledge. When the data were analysed in terms of knowledge on binder material, it was revealed that most respondents 48% had perfect knowledge of the mortar used with about 31% being completely unknowledgeable.

A similar pattern of responses can be observed in Figure 4 where knowledge is compared across building elements. When analysing roofing materials it is evident that moderate knowledge predominate followed by perfect knowledge while other knowledge levels make up less than 10% of all respondents. When we consider roofing material, slight knowledge predominates followed by perfect knowledge with the remaining knowledge level having less than 5% of all respondents. Lastly when binder is under consideration perfect knowledge

predominates followed by completely unknowledgeable and the remaining levels score less than ten.

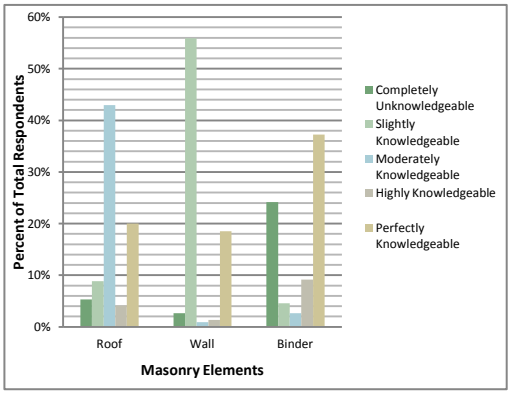

Figure 4: Knowledge diversity on building elements for respondents with knowledge on building design

Therefore in terms of structural components, respondents display a certain degree of diversity over the type of structural component being examined. While the design of the structure might be well known among the local community, the majority might have scanty knowledge about the walling materials, a moderate knowledge on roofing materials and a perfect knowledge on binder materials. A similar pattern is also observed for those without knowledge of the design of buildings or structures.

3.4.1 Sources of Knowledge on Building Elements

The results for the multinomial logit model implemented in SPSS yielded a summary of significant variables for each of the twelve models estimated (Figure 5). The presentation is not based on the estimated log values of the relative knowledge levels but on their exponentiated values. This facilitate interpretation as Exp(B) is the probability associated with the estimated knowledge level when compared to completely unknowledgeable.

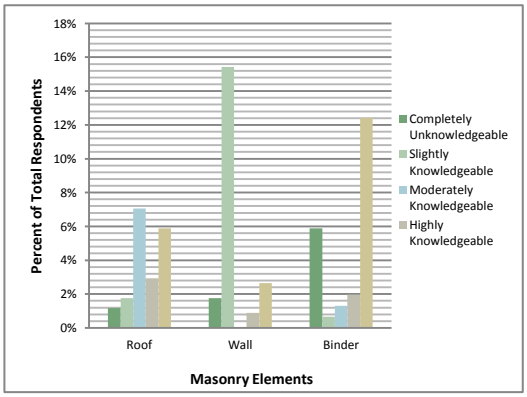

Figure 5: Knowledge diversity on building elements for respondents without knowledge of building design

3.4.2 Knowledge on Binder Materials

Different levels of knowledge on binder materials can significantly be traced on a number of variables. Perfectly knowledgeable can be traced through seven variables which are EDUC (1.13), AGE (1.03), SEX (1.76), OCOCW (-0.46), OCPES (-0.69), PREP (1.91) RESP (3.23). A year of additional schooling tends to increase the likelihood of being perfectly knowledgeable by 1.13, An additional year older person has 1.03 more chance of being

perfectly knowledgeable and males are 1.76 more likely to be perfectly knowledgeable than females. Occupation in conservation work reduces the probability of being perfectly knowledgeable by 0.46 while peasantry reduces by 0.69. Participation in preservation is likely to increase the probability of being perfectly knowledgeable by 1.91 while residency in a preserved building will increase such probability by 3.23.

Highly knowledgeable can be traced through ten variables which are EDUC (1.17), AGE (-0.99), SEX (-0.7), RDUNDA (-0.49), RMAGO (-0.19), OCOCW (-0.57), OCBUS (-12.98), PREP (2.45) PVISIT (3.86) and RESP (1.67). A year of additional schooling tends to increase the likelihood of being highly knowledgeable by 1.17, A one year older person has an 0.99 less chance of being highly knowledgeable and males are 0.7 less likely to be Highly knowledgeable than females. Proximity to heritage site at Dunda reduces the probability of being highly knowledgeable by 0.49 while residency at Magomeni reduces it by 0.19. Occupation in conservation work reduces the probability of being highly knowledgeable by 0.57 while occupation in business reduces by 12.98. Participation in preservation is likely to increase the probability of being highly knowledgeable by 2.45, preservation visits increases by 3.86 while residency in a preserved building will increase such probability by 1.67.

Moderately knowledgeable can be traced through seven variables which are EDUC (1.97), AGE (1.42), SEX (-0.14), OCFIS (-0.23), OCPES (-0.38), PVISIT (-0.01) and RESP (24.40). A year of additional schooling tends to increase the likelihood of being moderately knowledgeable by 1.97. A one additional year older person has an additional 1.42 chance of being moderately knowledgeable and males are 0.14 less likely to be moderately knowledgeable than females. Occupation in fishing reduces the probability of being moderately knowledgeable by 0.23 while peasantry reduces by 0.38. Visitation to preserved site is likely to reduce the probability of being moderately knowledgeable by 0.01 while residency in a preserved building will increase such probability by 24.4.

Slightly knowledgeable can be traced through eight variables which are EDUC (-0.92), AGE (-0.93), OCOCW (-0.20), OCBUS (-0.27), OCPES (-0.15), PREP (-33.94), PVISIT (-0.15) and RESP (3.12). A year of additional schooling tends to reduce the likelihood of being slightly knowledgeable by 0.92. A one year older person has 0.93 less chance of being knowledgeable. Occupation in conservation work increases the probability of being perfectly knowledgeable by 0.2 and occupation in Business reduces it by 0.27 while peasantry reduces by 0.15. Participation in preservation is likely to reduce the probability of being knowledgeable by 33.94 while visitation to a preserved site will reduce such probability by 0.15.

3.4.3 Knowledge on Walling Materials

Different levels of knowledge on walling materials can significantly be traced on a number of variables. Perfectly knowledgeable can be traced through six variables which are EDUC (1.13), AGE (1.03), SEX (1.76), OCPES (-0.69), PREP (1.91) RESP (3.23). A year of additional schooling tends to increase the likelihood of being perfectly knowledgeable by 1.13, a one year older person has an additional 1.03 chance of being perfectly knowledgeable and males are 1.76 more likely to be perfectly knowledgeable than females. Occupation in conservation work increases the probability of being perfectly knowledgeable by 0.46 while peasantry increases by 0.69. Participation in preservation is likely to increase the probability

of being perfectly knowledgeable by 1.91 while residency in a preserved building will increase such probability by 3.23.

Highly knowledgeable can be traced through ten variables which are EDUC (1.17), AGE (-0.99), SEX (-0.7), RDUNDA (-0.49), RMAGO (-0.19), OCOCW (-0.57), OCBUS (12.98), PREP (2.45) PVISIT (3.86) and RESP (1.67). A year of additional schooling tends to increase the likelihood of being highly knowledgeable by 1.17, A year older person has an 0.99 less chance of being highly knowledgeable and males are 0.7 less likely to be highly knowledgeable than females. Proximity to heritage site at Dunda reduces the probability of being knowledgeable by 0.49 while at Magomeni reduces it by 0.19. Occupation in conservation work increases the probability of being highly knowledgeable by 0.57 while occupation in business increases by 12.98. Participation in preservation is likely to increase the probability of being highly knowledgeable by 2.45, preservation visits increase by 3.86 while residency in a preserved building will increase such probability by 1.67.

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Slightly knowledgeable can be traced through eight variables which are EDUC (-0.92), AGE (-0.93), OCOCW (-0.20), OCBUS (-0.27), OCPES (-0.15), PREP (33.94), PVISIT (-0.15) and RESP (3.12). A year of additional schooling tends to reduce the likelihood of being slightly knowledgeable by 0.92. A year older person has 0.93 less chance of being slightly knowledgeable. Occupation in conservation work reduces the probability of being slightly knowledgeable by 0.2 and occupation in business reduces it by 0.27 while peasantry increases by 0.15. Participation in preservation is likely to increase the probability of being slightly knowledgeable by 33.94 while visitation to a preserved site will reduce such probability by 0.15.

3.4.4 Knowledge on Roofing Materials

Different levels of knowledge on roofing materials can significantly be traced on a number of variables. Perfectly knowledgeable can be traced through seven variables which are EDUC (1.23), AGE (1.10), SEX (-0.57), OCFIS (-0.07), OCPES (-2.52), WPRE (-0.07), PVISIT (6.19). A year of additional schooling tends to increase the likelihood of being perfectly knowledgeable by 1.23. A year older person has an additional 1.10 chance of being perfectly knowledgeable and males are 0.57 less likely to be perfectly knowledgeable than females. Occupation in fishing reduces the probability of being perfectly knowledgeable by 0.07 while peasantry reduces by 2.52. Working in preserved building is likely to reduce the probability of being perfectly knowledgeable by 0.07 while visitation to a preserved site will increase such probability by 6.19.

Highly knowledgeable can be traced through ten variables which are EDUC (1.16), AGE (-0.96), SEX (1.42), OCBUS (5.21), OCFIS (-0.43), OCPES (4.49) and WPRE (-0.02). A year of additional schooling tends to increase the likelihood of being highly knowledgeable by 1.16. A year older person has 0.96 less chance of being highly knowledgeable and males are 1.42 more likely to be perfectly knowledgeable than females. Occupation in business increases the probability of being highly knowledgeable by 5.21 while occupation in fishing reduces by 0.43 and in peasantry increases it by 4.49. Working in preserved building is likely to reduce the probability of being highly knowledgeable by 0.02.

Moderately knowledgeable can be traced through eight variables which are EDUC (1.11), AGE (1.05), SEX (-0.55), OCOCW (1.96), OCBUS (2.74), OCFIS (-0.32), WPRE (-0.03) and RESP (5.92). A year of additional schooling tends to increase the likelihood of being moderately knowledgeable by 1.11. A year older person has 1.05 more chance of being moderately knowledgeable and males are 0.55 less likely to be moderately knowledgeable than females. Occupation in other conservation works reduces the probability of being moderately knowledgeable by 1.96, and occupation in business increases it by 2.74 while occupation in fishing reduces by 0.32. Working in a preserved site is likely to reduce the probability of being moderately knowledgeable by 0.03.

Slightly knowledgeable can be traced through eight variables which are EDUC (1.10), AGE (1.17), RDUNDA (18.89), SEX (-0.46), OCOCW (3.80), OCBUS (-0.25), OCFIS (-0.48), OCPES (8.76), WPRE (-0.02), PVISIT (-0.43) and RESP (9.33). A year of additional schooling tends to increase the likelihood of being slightly knowledgeable by 0.10. A year older person has an additional 1.17 chance of being slightly knowledgeable. A male person has 0.46 less chance of being slightly knowledgeable compared to females. Residency in Dunda increases it by 18.89 and occupation in conservation work increases the probability of being perfectly knowledgeable by 3.80 and occupation in business reduce it by 0.25 while occupation in fishing reduces it by 0.48 and peasantry increases it by 8.76. Visitation to a preserved site is likely to reduce the probability of being slightly knowledgeable by 0.43 while participation in preservation will increase such probability by 9.33.

3.5 Classification of Sources of Knowledge

Figure 6 displays the extent of indigenous knowledge based on the significance scores. For presentation and ranking purposes the scores are presented as one less the sigma values resulting from significance tests. The results are classified into three main categories. The first are those variables which undoubtedly have a significant effect on the level of knowledge. These are significant determinant of the log odd of knowledge about building elements under consideration. The second category involves those variables whose effect is indeterminate, that is researchers are unable to conclude whether a particular variable has a general effect on knowledge about building elements of historic structures. The third are those variables with insignificant effect, hence are considered not a source of knowledge about building elements among indigenous communities.

By looking into the changes in the gradient of lines shown in Figure 6 we have come to the conclusion that the most significant factor that explains knowledge is education followed by age, occupation as a peasant and residency in a preserved building. A second set of variable may moderately explain the level of knowledge on building elements include visitation to

preserved buildings, occupation in other conservation activities, preservation participation, occupation in fishing activities and working in preserved building. The last category comprises variables which have a lower and insignificant likelihood of explaining different levels of knowledge on building elements; these are occupation in business, preservation experience, residency in Dunda, residency in Magomeni, occupation category being building heritage services and residency in other wards.

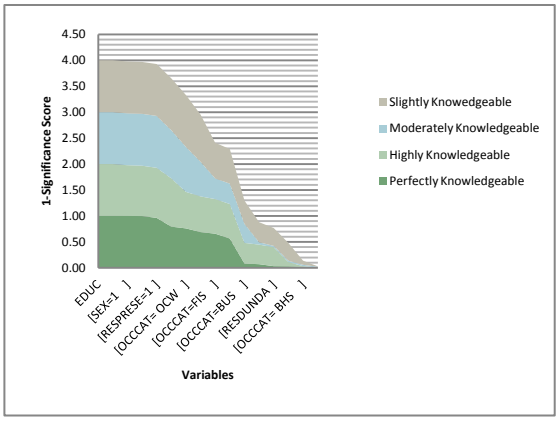

Figure 6: Significance ranking of explanatory variables for knowledge on building elements

Discussion of the findings

The results presented so far give a clear picture that we can rely on indigenous knowledge to prioritise heritage preservation strategies across heritage item. The local communities are well aware of the condition of buildings and can ascertain to a greater extent the current condition of such building heritage. If building condition is a criterion for immediate attention in a preservation strategy such as conservation, then we could evoke local knowledge on building condition and based on the findings in this study the Customs House would be the first building in the preservation programme. This assumes that Bagamoyo resident's preferences on condition reflect values attached to those buildings. However it should be noted that the analysis though cross-sectional is based only on the most known buildings.

A close examination of the Customs house (Figure 7) reveals that the building has significantly changed when compared to old images. The two towers that were located to the southern side are at the verge of collapse and the fence wall that used to surround the building is no longer. Efforts to rehabilitate the building have often proved futile as the materials used are not compatible to existing historic fabrics. It can be observed in Figure 7 that the customs house had two floors but the upper floor has been changed with modifications incorporating modern construction materials. Indeed this building requires special attention in any future preservation plan.

Figure 7: The Customs House: The majority of indigenous people regard this building to be in a poor condition.

On the other hand local communities can be a potential source of evidence on the preservation initiatives. They have identified the Old Post Office as a building in Good condition (Figure 8). The building is currently being used as a hotel and benefits from periodic maintenance carried out possibly to attract customers. Despite some of the modifications that can be seen around the building, most historic item has been preserved. The dynamics through which the building has passed can still be observed. When compared to other good buildings, it is evident that the Old Post office is highly under active preservation, there is no sign of wearing of plaster as in most other buildings. The current use as a hotel seems to be compatible with the heritage nature of the old stone town. Being a hotel has not prevented the building from visitation. The ground floor is still accessible where photos and historical narrations are displayed.

Apart from using indigenous knowledge to prioritise preservation of historic building, local communities can play a crucial role as conservationists. Based on the findings in this paper, the most likely form of contribution that one may expect from local communities within Bagamoyo is manual labour. Manual labour is crucial when preservation is conservation based and building elements need replacement or when restoration is sought. The Bagamoyo residents could provide casual labour to support construction and rehabilitation activities. They might also be useful in providing cleanliness and security services. There are also other areas for which there is a small chance of getting local people especially in cultural services such as tour guide or reception services. These activities may need employment rather than engagement of indigenous people. However one should be cautious of this PPC as it is almost on equal footing to contributing nothing when the frequencies of responses are considered. Likewise income should not be relied upon in targeting individuals for PPC.

4.1 Empirical sources of Knowledge on Building elements

The physical characteristics of building elements could be understood by local people based on customs and tradition relating to construction. Most historic structures at Bagamoyo were constructed based on imported technology hence local communities have learned through time and are highly aware of the technology. However evidence availed in this paper suggests that knowledge on building elements of historic structure vary significantly across building elements as well as knowledge levels. One may not expect indigenous people portraying the same level of knowledge throughout the demographic cluster or even

throughout occupation categories. This diversity can be explained by a number of factors ranging from inborn skills, and talents to learning acquired through formal education.

Based on the classification in this paper, factors that could provide some insight into knowledge diversity are classified into five classes (Table 5). The first class has five (5) variables which are significantly related to knowledge on building elements. The results show that the variable EDUC is positively correlated to knowledge on building elements throughout knowledge level. This is a clear indicator that respondents might have obtained knowledge about building elements through formal education or more likely formal education increasing the chance for a person to develop some interest on historic structures. The coefficients for AGE are also significant throughout knowledge levels. This means that age has a strong relationship with knowledge on building elements of historic structures. With the exception of those who are highly knowledgeable and those who are slightly knowledgeable especially on walling and binder materials the effect of higher age is to increase the log odd of knowledge on building elements. The general effect is positive meaning that the higher the age the more likely that an indigenous person might be knowledgeable about the three building elements.

The above two variables provide an indication of learning among indigenous population which might be taking place through both formal and informal means. Formal education portrays learning in the general educational context where people inculcate active knowledge and diversify their interest in historic structures. Formal education may not necessarily be about building elements rather the learners may acquire interest through formal education and acquire knowledge about the building elements through an informal channel. Age portrays an informal way of learning where; as a person becomes older the more experience, the more travels, the more stories and other educative media he/she is likely to have encountered. Older people are more likely to be knowledgeable on building elements rather than younger people.

Residency in preserved building (RESP) enhances knowledge on building elements of historic structures. It can be observed that residency in a preserved building tends to be positively correlated to the log odd of knowledge on building elements throughout the knowledge levels. The variable sex is significantly related to knowledge on building elements. However the relationship depends on the level of knowledge under consideration and the type of building element. Being male increases the log odd of perfect knowledge on walling and binder material by 0.57 while reducing it for roof material by the same margin.

A similar effect can be observed for the log odd of highly knowledgeable. Being males reduces the log odd of moderate knowledge and again increases for slight knowledge on walling and binder material while reducing for roof. With this confusion, there is no general conclusion on the effect of sex being males on the level of knowledge for building elements. What can be concluded is that for walling and binder material Sex of being male is likely to increase the log odd of perfect and slight knowledge while reducing for High and moderate knowledge. For roofing materials, being male seems to reduce the log odd of knowledge with the exception of high knowledge.

Being a fisherman (OCFIS) is significantly correlated to knowledge on building elements. The effect of the variable OCFIS is negative for almost all knowledge levels with the exception of those with high knowledge on walling and binder materials where the effect on the log odd of highly knowledgeable is positive. However the general conclusion is that if the occupation fisherman is compared to unemployed people, the log odd of knowledge on building element is likely to be lower among fishermen.

The second group of variables comprises those variables whose significances were generally not determined. Visitation to preserved site (PVISIT=1) significantly explains slight knowledge only while failing to explain other knowledge levels. The effect of this variable is indeterminate as it insignificantly reduces the log odd of perfect knowledge for walling material while significantly increasing for binder and roof; significantly reduces moderate knowledge for walling and binder materials and insignificantly increases for roofing material; it significantly reduces slight knowledge on all building elements and significantly increases the log odd of high knowledge on all building elements. Therefore visits to preserved building might enhance the log odd of highly knowledgeable when compared to those who are completely unknowledgeable while it is likely to be lower among those with slight knowledge.

In this second category we also have the variable OCPES which reflects those respondents fully occupied in farming (peasantry). Being a peasant has a negative effect on knowledge about walling and binder and a positive effect on roofing material throughout knowledge categories. Being peasant insignificantly reduces the log odd of knowledge on walling and binder material across knowledge levels except for highly knowledgeable for which it is significant but still negative. Contrary to that occupation as peasant in comparison to being unemployed, significantly increase the log odd of knowledge on roofing material across knowledge levels.

Lastly we have a third category comprising 9 variables with insignificant effect on the log odd of knowledge on building elements. Residencies in other wards (RWARD=(Others) i.e. not being Magomeni or Dunda), the variables workplace is a preserved building (WPR=1), Preservation Participation (PPA=1), Preservation Experience (PEXP=1) and OCBHS have a positive correlation with the log odd of knowledge though not statistically significant. Occupations in other conservation activities (OCOCW), Business (OCBUS), Residency is Dunda ward (RDUNDA) and Residency is Magomeni (RMAGO) are statistically insignificant as explanatory variable for the log Odd of knowledge with indeterminate effect. Thus residency in Dunda or Magomeni or occupations in conservation work or business does not correlate significantly with the log odd of knowledge throughout the knowledge level.

Table 5: Significance of Parameter estimates and the nature of effect on the response variable

Variables	**Significance Scores**				**Nature of Effect**
	Perfectly Knowledgeable	**Highly Knowledgeable**	**Moderately Knowledgeable**	**Slightly Knowedgeable**	
EDUC	0.00	0.00	0.00	0.00	Positive
AGE	0.00	0.00	0.00	0.00	Positive

[RESPRESE=1]	0.00	0.02	0.00	0.00	Positive
[SEX=1]	0.00	0.03	0.00	0.00	Indeterminate
[OCCCAT=FIS]	0.04	0.04	0.00	0.00	Negative
[PREVISIT=1]	0.21	0.07	0.07	0.00	Indeterminate
[OCCCAT=PES]	0.24	0.30	0.13	0.00	Indeterminate
[RESWARD=Others]	0.31	0.31	0.33	0.09	Positive
[OCCCAT=OCW]	0.34	0.33	0.60	0.31	Indeterminate
[OCCCAT=BUS]	0.44	0.33	0.61	0.33	Indeterminate
[WORKINPR=1]	0.92	0.60	0.63	0.55	Positive
[PRESERPA=1]	0.93	0.62	0.95	0.61	Positive
[RESDUNDA]	0.97	0.64	0.97	0.66	Indeterminate
[PRESEREX=1]	0.97	0.92	0.97	0.66	Positive
[RESMAGO]	0.98	0.99	0.98	0.92	Indeterminate
[OCCCAT=BHS]	1.00	1.00	0.98	0.99	Positive

4.2 Targeting Participants using Indicator Variables

The understanding of most significant factors determining knowledge on building elements could be important in preservation especially when targeting of participant is at hand. Apart from Age and education level, it is important to consider residency in a preserved building. The significance of the variable RESP indicates a need to carefully target historic building residents rather than owners in the preservation of historic buildings. Owners not living in a historic building may not necessarily be knowledgeable about the changes that are happening to the building, about the weak points and may not even be interested to know. However in terms of legal issues owners must be consulted before any preservation strategy is implemented.

In targeting individuals to be included in the preservation team care should be taken on the current occupation of the person. It has been clear that fisherman when compared with unemployed people have a significantly lower likelihood of being knowledgeable about building elements. Hence we have a limited knowledge base among fisherman and one may need to consider an unemployed person if building element replacement or restoration is at the centre of preservation. Therefore in targeting potential participants, local communities engaging in fishing may need to be avoided unless there is a clear indication of interest in heritage preservation.

Likewise sex being male which is a significant determinant of knowledge on building elements cannot be used as a panacea to selecting participants in a preservation strategy. Indigenous male individuals do not appear to be above or lower than female. What has been observed is that for walling and binder material sex being males is likely to increase the log odd of perfect and slight knowledge above that of females while reducing for high and moderate knowledge below that of females. For roofing materials, being male seem to reduce the log odd of knowledge below that of females with the exception of high knowledge into which it increases.

Therefore for the category slightly knowledgeable and perfectly knowledgeable males have a higher likelihood of being in those knowledge levels than females. However, given the fact that they are two extremes it is difficult to conclude whether males are knowledgeable than females or otherwise. We reserve this paradox for further studies but for the time being it suffices to say that females and males seem to be equally knowledgeable about building elements of historic structures. This being the case gender based discrimination in selecting potential participants in the preservation strategy need to be avoided. This finding matches well the requirement to uphold social values attached to building heritage sites (Monika Therrien, 2006)

Further it should be noted that indeterminate variables such as visitation to preserved buildings or occupation being peasant are ambiguous. They might be significant determinant when one category is being analysed and not significant for the other. Likewise the variable PVISIT tends to be negatively correlated to knowledge on walling and binder materials at knowledge level perfectly knowledgeable, moderately knowledgeable and at slightly knowledgeable. This means that at these levels visits to heritage site has a lower chance of adding knowledge when compared to non visits. While visitation to building heritage site may be a useful tool to obtain historical values, it can limitedly be used as a learning devise for understanding building elements. Likewise the variable OPES seem to fall within the same category of PVISIT. Targeting for inclusion into a preservation plan may involve certain criteria to assess knowledge on building elements for those highly dependent on visitation or who seem to be fully occupied in farming.

It should be clear that knowledge on building elements does not depend on proximity to heritage site nor participation in previous preservation activities. It has further been established that preservation experience and occupation in business activities does not provide a good explanation for diversity in knowledge. The analysis carried out so far suggests that knowledge on building elements of historic structures is constructed and can be acquired through learning. Across age groups and across occupation there is a wider diversity of knowledge about building elements. As the buildings fed out, knowledge on these buildings tends to stay with local communities. Therefore in any preservation strategy, meaning and understanding of building elements over time can be accessed through community participation. An understanding of the five significant explanatory variables for different knowledge levels may help in targeting prospective participants in preservation planning and management.

5.0 Conclusion

At the centre of preservation of historic structures is community participation. This entails potential contribution from indigenous population. The Bagamoyo building heritage site is

likely to get more contribution from indigenous in the form of manual labour with the least contribution coming from direct heritage services and other crosscutting services. However there is significant reluctance among local communities to actively participate in preservation which is almost as strong as the provision of manual labour. Therefore we cannot be 100% sure of potential contribution in the form of manual labour rather one can expect significant contribution in manual labour among those who are willing and able to contribute. Despite the fact that participation is ambiguous, indigenous people in Bagamoyo have enormous resource in the form of diverse knowledge on building elements which could be harnessed for effective preservation of historic structures. This knowledge base on building elements can unambiguously be traced through education, age, sex, residency in preserved building and among people fully occupied as peasants. If one is interested in imparting knowledge about building elements of historic structure, an appropriate approach is to let the learner experience the material by either living, going through a formal education system or through continued contact with the historic building over years. However local visitors can participate in preservation given they are indigenous and have additional attributes which will allow them make significant impact in the intended preservation.

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Towards Effective use of Information and Communication Technology (ICT) Application in the Healthcare Management: A Descriptive Study of Online Appointment System Services of Hospitals in India

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Abstract
This research work investigates Online Appointment System Services offered by hospital websites to study the effective use of information and communication technology. Medical appointments allow sufficient time for each patient's medical condition to be examined thoroughly. Among various methods used in booking appointments, online appointment booking is promising. This research work aims to investigate the Online Appointment Service of Hospitals in India, to assess online appointment service process and to build an improved online appointment model. Descriptive research method was employed in the study. There are a few multi-speciality hospitals offering online appointments for consultations, but most hospitals in India are yet to initiate online appointment facility. The proposed new online appointment model which has evolved out of this research work suggests efficient solutions to enable hospitals to provide better healthcare delivery using ICT applications.

Key Words: Online Appointment System Services, Information and Communication Technologies, Healthcare Delivery, Inter-networked Healthcare Delivery

Introduction
Information and Communication Technology Applications in Healthcare
Information and Communication Technology (ICT) has improved the healthcare delivery mechanisms, like improvements in service efficiency and information dissemination (Peter Idowua Dan et. al, 2008). According to a report by the European Commission (2011), four categories of ICT applications and tools for health was distinguished. (i) Services addressing health prevention, diagnosis, treatment, long-term care, telemedicine. (ii) Support activities like Electronic Patient Record, Picture Archiving and Communication Systems, ePrescriptions, health portals, Hospital Information Systems. (iii) Provision of health knowledge infrastructure, medical education, medical research and clinical trials. (iv) IT infrastructure for physical networks allowing connectivity, interoperability, and regulatory framework related to secure transmission, secure processing and storage. As the health care industry moves toward the advancement of a personalized health experience, methods to improve the access, efficiency, effectiveness and quality of the processes has become important (Tomasi, Facchini and Maia, 2004; Arthur Hylton III and Suresh Sankaranarayanan, 2012).

A. Online Healthcare for patients

Information and Communication Technologies such as the Internet, the quality of patient care doesn't end with good bedside manner. The Internet has great potential for increasing patients' access to health information could integrate patient management and health information management into a single, flexible system that is easy to use and maintain (Jodiê Smith, Suresh Sankaranarayanan, 2012).

Initially, the health care industry has been slow in accepting the use of advanced information systems. In most hospital practices, Hospital Information Systems for many years relied on paper based systems, for task like appointment scheduling and in maintaining medical records (Marques et al, 2011). This research investigates the use of one component of ICT tools used in Hospital Information Systems, the Online Medical Appointments through hospitals' website and assess it quality of service.

Medical Appointments

According to the Medical Dictionary by Farlex, Medical Appointment is a mutually agreed-on time reservation for patient to receive treatment (medicaldictionary.com). From a patient point of view, appointment-making is the time the patient wish to consult a doctor to avoid unnecessary waiting at the hospital.

A medical appointment is most often scheduled over the telephone or in person (Patient Scheduling, 2013). According to Centre for Disease Control and prevention (2004), an appointment is scheduled to define a date, time, location and resource for the clinical encounter to have the order carried out.

B. Types and Methods of booking Medical Appointments

There are two types of medical appointments, scheduled appointments and unscheduled appointments. Unscheduled appointments do not require any booking and involves patients' walk-ins to the hospital or clinic. In Scheduled appointments, the patient confirms the availability for the offered appointment time through Phone, SMS, or internet

Table 1: Unscheduled Method of booking Medical Appointments

Method	Features	Merits	Demerits
Walk-in	Appointment not scheduled First come, first serve basis Worked in to existing schedule	Appropriate for urgent or emergency cases	Patients kept in queue Unacceptable waiting times Great stress on hospital/clinic staff Exorbitant paper work

Source:

Diwakar Gupta and Brian Denton, 2008, Press Ganey Associates, Inc. 2010, Patterson Companies, Inc. 2012, Arthur Hylton III and Suresh Sankaranarayanan, 2012; Patient Scheduling, 2013

Table 2: Scheduled Method of booking Medical Appointments

Methods	Features	Merits	Demerits
Phone	Patients call hospital and fix appointment in advance	Overall reduction in time wastage Quick appointments	Overcrowding of hospital telephone lines Unable to be answered at all times Obtaining limited patient information Time- and resource-draining process
Interactive Voice Response (IVR) Automated Phone	Computer or machine interact with humans through the use of voice and dual-tone multi-frequency signalling (DTMF) keypad inputs Pre-recorded/dynamically generated audio for caller navigation through appointment system	Services high call volumes Reduces cost, and improve the customer experience Convenient to call a dedicated line for appointment Confirmation SMS immediately after fixing appointment	Relatively a year old and the ease of its use is yet to be assessed
SMS	SMS request to mobile/short coded number Prior registration of user mobile number mandatory Message format given by service provider	Patient data automatically stored in database SMS confirmation after fixing appointment Convenient to fix or cancel appointment Automatic reminder by SMS to Patient, Doctor and Hospital regarding appointment	Success of this system depends largely on the reliability of the mobile service provider
Internet	Appointments via web-connected device such as a computer, laptop, smartphone or tablet 24/7 virtual medical receptionist Available on web site by hospital/clinic or web portal Appointments online requires a patient or his/her represented family physician reserve consultation time by entering name, family name, mobile	User-friendly technology, more popular Booking from anywhere, anytime No human assistance and hence, no human errors. Cost-effective Effective optimization of scheduling process	Not an option for most patients Internet access, skill, preferred language required for online activities Privacy maintained but not a guarantee

	phone number and other contact information of patient. Specialist can be chosen by health care institution, family name, speciality and consulting-room or by the set of all these criteria. Customizable date and time slot display (Online Calendar) Notes for each appointment recorded by each Consultant Multiple level of user security & user groups Customisable resource (such as room, equipment) management Customisable client customer data fields	Doctors organise best practice sessions, better interaction Avoids waiting time 24 hours convenience Viewing daily weekly and monthly patient schedules made easy Patient view doctors schedule and select convenient dates Automatic confirmation of booking and instant recording Cancellation of appointment is possible Multiple views (such as daily view, weekly view, consultants view) on appointments Recording, updating and accessing patient information is made easy Recurring appointments for multiple patient visits Avoid no-show, missing, overbooking appointments or other conflicts Reduced Paperwork Easy to track insurance coverage Easy to find vacant scheduled time Simplifies cross-scheduling, and the directing of patients to other offices	

Source:

Phone: O. A. Akadiri et.al. 2009, Ryan Field et. al. 2011, Appointment -Plus, 2012
Interactive Voice Response (IVR) Automated Phone: Computer Weekly News, 2013, Khaleej Times, 2013
SMS: Vilnius, 2008;
Internet: Kopach et. al. 2007; Richard Lango, 2009; T. Edwards and S. Suresh, 2009; George Ruth, 2009; Aubrey Andrew, 2010; Gayathri, 2013

Table 3: Internet based Online Appointment Booking – Web Portal and Hospital/Clinic Website

Method	Features	Merits	Demerits
Internet (Web Portals)	Creates a single, customizable point of access to any **consortium of health care providers** registered in the portal Patients make appointments online with various care providers **Two-way communication channel between patients and a consortium of health care providers** Patients book appointments by logging in and selecting from a menu of choices. Displays available appointments by provider, time slot, clinical session and/or day of the week **Web portals act like outsourcing appointments**	**Convenient, 24 hour, self-service options** **Patients book appointments at nearest hospital/clinic** Efficient use of resources and possibility for patients to choose services of specialists from different health care institutions System helps automate patient reminders, which, again, reduces the time pressures on practice administrative staff Outsourcing appointment patients to call in and schedule appointments in vacant time slots	Common web portals are not available in all countries Lack of information about common web portals The success depends upon the common web developers
Internet (Hospital/Clinic Website)	Provides patients with more specific information on the respective hospital's websites Online appointment system through dedicated web page can be integrated with a	Hospital website are more reliable than web portals Hospitals employ dedicated staff for follow-up Assistance from hospitals is an added assurance	All hospitals/clinics do not have a website Lack of information about the availability of the service to the patients or users

	hospital/clinic website.		Not an option for most patients Internet access, skill, preferred language required for online activities

Sources:
Internet (Web portals): Report of the Health ICT Industry Group, 2009; **Elizabeth W. Woodcock, 2011;** ICT News, 2013
Internet (hospital/clinic websites): Cao Yin, 2011

Literature Review – Application of Online Appointment System Services in hospitals, worldwide.

The East Tallinn Central Hospital was the first in Estonia to introduce an ePatient portal through the hospital's website and found to be very successful. Access is through the hospital's website, and the portal allows patients to view their medical records, to book medical appointments and pay consultation fees. Patients reported that the system made convenient appointment booking from their homes (European Commission, 2011).

Patient Appointment Reservation System was introduced in 40 different health care institutions in Lithuania to improve the quality of health care services increasing the availability, expedition and the effectiveness of the information of physicians' visits time. Since the beginning of this project in 2008 patients appointment reservations via Internet have been increasing steadily. The system proved to be a great advantage for the patients and primary care physicians and its use have been steadily rising till date (Vilinius University Hospital, 2008).

The public health portal 'Sundhed.dk' in Denmark integrates health-related data from disparate health care systems throughout Denmark. Patients can schedule a medical appointment using the portal's scheduling module. Patients experience more benefits like receiving appointment confirmation via e-mail, and sees as a quick relief of being tied to the phone. (Report of the Health ICT Industry Group, 2009).

Makerere University Hospital, Uganda, introduced an online appointment system to access doctors' schedules and book appointments. A study on this system by Atwine et.al. (2009) found that the administrators used the system to register new users, edit schedules and view pending results. A short messaging system has been interfaced through the system to ensure communication between patients and doctors.

Between 2006 and 2009, a Healthcare Online Programme, an initiative launched by the Spanish government to accelerate Spain's integration into the Information implemented online appointments in all primary care health centres to book appointments with General Practioners and Paediatricians. A study report of the programme states that by 2006 more than 12 million appointments to see paediatricians and GPs were requested online. Nearly 86% of Spanish citizens registered at the 3,321 primary care Health Centres that offered the Online appointments service. The study also revealed that by the end of 2009 about 37 million citizens benefitted from the online appointment service in the National Health

System, which represents a 67% increase over two years (Report of the Healthcare Online programme, 2010).

Extended waiting times for a medical appointment continued to be problematic in China. To address this issue, a web-based appointment system was developed for the Xijing hospital. Cao et al. (2011) studied the efficacy of the system and found that compared to the usual queuing method, the web-based appointment system could significantly increase patient's satisfaction. With online registration, total waiting time was effectively reduced. Lack of information about online appointments was the main reason for most of the patients not using the system.

Methodology

Objectives of the research

- To investigate the Online Appointment Service of hospitals in India
- To assess hospital's Online Appointment service process
- To build an improved online appointment model suitable for hospitals in India

C. Research Method

Descriptive research design was used for this study. According to Burns and Grove (2003), descriptive research "is designed to provide a picture of a situation as it naturally happens". It may be used to justify current practice and make judgment and also to develop theories. There are three main types of descriptive research design: observational methods, case-study methods and survey methods. For the purpose of this study, observation method was employed to obtain information used in the hospital's website that provide online appointment service for patients. Observation method is used when no intervention is made (in contrast with an experimental method). Such method provide estimates and examine associations of events in their natural settings without recourse to experimental intervention (C J Mann, 2003).

Survey of Online Medical Appointment Application through Hospital websites

This research studies the application of Online Medical Appointments of hospitals in India and measures its quality of the process and excludes private web portals, as there are no dedicated and authentic web portal for booking appointments approved by any hospitals or government in India.

D. Choice of Sample population and its determination

India houses many hospitals both public and private. To identify the sample population across the states of India, the authors searched for a list of hospital data what was selected based on a scientific investigation. A rating study by The Week and HANSA on 2011 India's Best Hospitals, published in The Week magazine on December 12, 2012 (The Week-HANSA Research Survey, Full Report, 2012) was chosen.

Background of The Week and HANSA Research

To determine India's Best Hospitals, hospitals with a minimum of 100 beds, which have completed at least 2 years of being operational, and which have received 5 per cent or more of the total nominations from physicians were included in the survey. The survey has taken factual data into account in the rankings. A primary survey was conducted among 917 Experts—328 general physicians, 442 specialists and 147 pathologists/radiologists.

A questionnaire was given to the experts asking them to nominate and rate the top five multi-speciality hospitals in India and within their city. Apart from this, 77 qualitative interviews that went beyond nominations and ratings were also done to get an in-depth understanding of the reasons for the rankings. An advertisement was printed in THE WEEK inviting hospitals to volunteer information. For multi-speciality hospitals in India, ranking was based on a composite score derived by combining the perceptual and factual score of the hospital. (The Week-HANSA Research Survey, 2012).

The Week and HANSA used the following parameters for rankings of the hospitals:

- overall reputation of the hospital,
- competency of doctors,
- infrastructure,
- availability of multiple specialities,
- patient care,
- hospital environment and innovation in treatment

Sample Selection

All hospitals, excluding pathological, imaging centers from The Week and HANSA were taken for the study. Therefore 144 hospitals' from 18 cities ranked under the city and speciality wise was chosen for the study. The following are the hospitals selected, listed city wise. The figures in brackets refers to the total number of hospitals selected from each city and listed alphabetically.

1. Ahmedabad (Gujarat) (8)
2. Bangalore (Karnataka) (18)
3. Chandigarh (1)
4. Chennai (Tamilnadu) (16)
5. Coimbatore (Tamilnadu) (7)
6. Delhi (15)
7. Hyderabad (Andhra Pradesh) (11)
8. Indore (Madhya Pradesh) (6)
9. Kochi (Kerala) (7)
10. Kolkata (West Bengal) (10)
11. Lucknow (Uttar Pradesh) (5)
12. Ludhiana (Punjab) (4)
13. Madurai (Tamilnadu) (1)
14. Mumbai Maharastra) (12)
15. Nagpur (Maharastra) (5)
16. Pune (Maharastra) (8)
17. Thiruvananthapuram (Kerala) (9)
18. Vellore (Tamilnadu) (1)

For the list of Hospitals selected for the study, please refer to the Appendix I

The 144 hospitals' website were accessed between July 6th, 2013 and July 15th, 2013. Each hospital website was navigated to find if the website had the accessibility for online medical appointments for patients. Besides, the input of the hospital's structure was obtained from the website

The structure of the hospital refers to the following criteria:

1. Ownership pattern [Government Hospital (Center/State), Semi-Government, Voluntary Agencies, Charity Hospitals, Private/Corporate)
2. Locality (Urban, Rural, Semi-urban)
3. Speciality (various disciplines of medicine)
4. Objective (General, Speciality, Teaching-cum-research hospital)

Table 4: Estimated Sample population

S. No	Category	Items in each category	Number of Hospitals (144)	Total
1	**Ownership Pattern**	Central Government	7	
		State Government	18	
		Semi-Government	2	
		Voluntary Agencies	5	
		Charity Organisations	13	
		Private/Corporate	99	**144**
2	**Locality**	Urban	144	
		Rural	0	
		Semi-urban	0	**144**
3	**Hospitals by Speciality**	Multi-Speciality	55	
		Super-Speciality	29	
		General Hospitals	19	
		Multi-Super Speciality	13	
		Single Speciality	28	**144**
4	**Hospitals by Objective**	Speciality Services	100	
		General Services	6	
		Teaching-cum-research	38	**144**
5	**Hospitals owing website**		141	
	Hospitals without website		3	**144**
6	**Hospitals having online Appointment service**		**42**	
		Central Government	0	
		State Government	0	
		Semi-Government	0	
		Voluntary Agencies	2	
		Charity Hospitals	1	
		Private/Corporate Hospitals	39	**144**
7	**Specialities**	Multi-Speciality	20	

	having Online Appointment Services			
		Multi-Super Speciality	6	
		Super-Speciality	5	
		General	3	
		Single-Speciality	8	**144**
8	**Hospitals without online Appointment Service**		102	

Chosen and Determined *Sample Population*

The results of the study revealed that 42 hospitals from different cities have online Appointment system Services. Further it was noted that Apollo Hospitals have one common website for all the branch hospitals in Ahmedabad, Bangalore, Chennai, Delhi, Hyderabad, Indore and Kolkata; Fortis Hospitals have one common website for its branches in Bangalore, Chennai and Delhi; and Global Hospitals have common website for its Bangalore, Chennai and Hyderabad Hospitals. Hence Apollo, Fortis and Global Hospitals were taken as single unit Hospital for the study. 10 branch hospitals of the Apollo, Fortis and Global were consolidated for final analysis. Therefore, the sample hospitals thus taken for further analysis is 32. (**For the list of Hospitals selected for the study, please refer to the Appendix II)**

Measuring the quality of Online Appointment Process

To measure the quality of the Online Appointment System Services for the sample, it was found that several earlier studies dealt with models assessing a website or a portal in terms of information, appearance, usability, and privacy and security (Hsin H Chang and Ching S Chang, 2008) which does not fulfil the objective of the research. In search for a scientific model to assess the Online Appointment System a U.S. Patent No. 20110313806 by Ian Huang published on December 22, 2011 is used in this research to measure the Hospital's Online Appointment System Services. The Patent is published in the website of the US Patent and Trademark Office (Ian Huang, 2011).

E. Background of U.S Patent no. 20110313806 on Online Appointment Booking System

U.S Patent no. 20110313806 relates to an Online Booking System which can be used for example doctors, dentists and the like. The method explained in the patent has used a model appointments are made is in the medical field where a patient or user needs to book appointment with a family doctor who may then subsequently require the patient to book an appointment with a specialist, hospital, blood lab, X-ray Clinic or other scanning facility.

This patent published in December, 2011 have been an improved method on Online Booking Appointment System developed on the earlier online appointment methods for example U.S Patent No. 6.345, 260 and U.S 2010/0070303. This method claims to have filled the lacunae created by the earlier systems in terms of providing better search and display algorithms to provide a comprehensive booking service for patients, clients, doctors and the like.

Assessment of the Sample Population of 32 Hospitals in India providing Online Appointment service by comparing with components proposed by U.S Patent No. 20110313806

For assessing the sample population of the 32 hospitals in India providing Online Appointment service, the U.S Patent No. 2011030313806 is used. The patent relates to a web based information system that will enable patients (clients) to access doctors' schedules and book appointments online irrespective of the location and time.

The Patent describes the components involved for patients to register information that relates to patient's demographics details, time and date of appointment, health and medical data for completing the online appointment booking process. Each component is listed to identify how patients go through a series of steps to complete the online appointment process by providing individual patient data.

The Sample Population of 32 hospitals in India providing Online Appointment service is compared with each of the 25 components proposed in the patent.

Table 5: Results of the assessment of the Sample Population of 32 Hospitals with U.S Patent No. 20110313806

S.No	Components proposed in the Patent No. 20110313806	No. of hospitals having this item (32)
1	Patient Registration ID or Access Code	9
2	Search By Location	12
3	Search By Doctor	23
4	Patient's Name	27
5	Patient's Address	21
6	Patient's Phone Number (Telephone and Cellular Number)	26
7	Patient's email ID	24
8	Date of Birth	18
9	Gender	17
10	Appointment Type	1
11	Patient's Message	16
12	Doctor's email and Phone Number	0
13	Online Calendar for Appointment	23
14	Book Appointment with next available doctor	0
	Preferred date for booking	23
15	Preferred time for booking	12
16	Referral and Consent Letters	2
17	Local Government Health Identification Number	0
18	Health Insurance Company and Policy Number	1
19	Credit Card Number	0
20	Family Dependant Registration	0
21	Approval from Patients for Accepting Messages from	0

	Doctors/Hospitals	
22	Rebooking Appointments	0
23	Cancelling Appointments	1
24	Recall Appointments	0
25	Security Code	12

Discussion of evaluation with US Patent No. 20110313806 and Evolution of a new ground truth criteria for evaluation

It was observed that U.S Patent No. 20110313806 was insufficient to assess the quality of the online appointment services by the sample hospitals, as the hospitals had more significant components than that proposed by the Patent. When the rule becomes insufficient, then the sample population cannot be assessed against the rule and consequently a new rule has to be used for assessment. However, it is noted that there is no other rule other than the Patent to assess an online appointment system of hospitals. Consequently when the ground truth criteria is not available for evaluation, then a ground truth criteria can be evolved out of the entire population for assessment. With regards to online appointment system for hospitals, the entire population gets restricted to the chosen sample population as given in previous paragraphs. Further, the online appointment system of hospitals in the sample population differs substantially except in some areas where there is similarity. Therefore, the ground truth criteria can be evolved out of the sample population itself and can be used to evaluate the same sample population due to reasons of the sample population approximating the entire population and substantial difference between each of the hospitals in the sample population.

Each sample hospital is taken up and the observed components are listed. Similar components are excluded so as to avoid repeating it for more than one time. Whenever a new component is observed it is listed along with the other components. The process is repeated for all the 32 hospitals until all the observed components are fully listed. The components thus arrived at for the new ground truth criteria for evaluating the online appointment system in hospitals is given below.

F. Components of new ground truth criteria for evaluating online appointment system in hospitals (listed alphabetically)

1. Address of the emergency Contact Person
2. Alternative Choice of Date
3. Appointment Alternative Time choice
4. Appointment Category
5. Appointment Confirmation No
6. Appointment Date
7. Appointment Time
8. Appointment Type
9. Blood Group
10. Cancellation option
11. Captcha Code
12. Date of Birth
13. Doctors Profile
14. Doctors Schedule

15. Emergency Contact Person
16. Father's Name/ Spouse name
17. Gender
18. Health Insurance and Policy Number
19. Hospital Registration No/Access no
20. Insurance Company
21. Marital Status
22. Name of the Employer/Company
23. Nationality
24. Passport No and Date of Expiry of Visa for Foreign Nationals
25. Patient E-mail ID
26. Patient Message/Remarks/details about Symptoms
27. Patient Name
28. Patient Phone/Mobile No
29. Patient's Address
30. Phone No of the emergency Contact Person
31. Print Option
32. Profession
33. Referee Name
34. Relationship of the Patient to the Emergency Contact Person
35. Religion
36. Search by City
37. Search by Doctor
38. Search by Hospital
39. Search by Speciality
40. SMS/Phone/email Confirmation of using Online Booking
41. Upload Medical case
42. Upload Photo
43. User Email ID
44. User Name
45. User Phone/mobile No

Table 6: Evaluation of Sample Population of 32 Hospitals with Proposed New Ground Truth Criteria for evaluation of online appointment system of hospitals

- **Not Working** – 7 hospitals having online appointment system service did not function at the time of research.

S.No	Classification Category	Items in each Classification/Category	No. of hospitals having this item
1	**Pre-Appointment Booking facilitations**		
1.1		Hospital Registration No/Access no (one time access number)	9
1.2		Search by Doctor	23
1.3		Search by City	12
1.4		Search by Hospital	10

1.5		Search by Speciality	25
1.6		Appointment Category (first time or follow-up)	4
1.7		Appointment Type (consultation/diagnosis/health check-up)	1
1.8		Doctors Profile	2
1.9		Doctors Schedule	10
1.10		Appointment Date	23
1.11		Alternative Choice of Date	3
1.12		Appointment Time	12
1.13		Appointment Alternative Time choice	1
2	**Patient Demographics**		
2.1		User Email ID	2
2.2		User Name	5
2.3		User Phone/mobile No	4
2.4		Patient E-mail ID	24
2.5		Patient Name	27
2.6		Patient Phone/Mobile No	26
2.7		Date of Birth	18
2.8		Nationality	11
2.9		Gender	17
2.10		Father's Name/ Spouse name	3
2.11		Marital Status	3
2.12		Patient's Address	11
2.13		Profession	4
2.14		Name of the Employer/Company	2
2.15		Religion	2
2.16		Upload Photo	1
2.17		Emergency Contact Person	2
2.18		Relationship of the Patient to the Emergency Contact Person	1
2.19		Address of the emergency Contact Person	2
2.20		Phone No of the emergency Contact Person	2
2.21		Passport No and Date of Expiry of Visa	1
2.22		Referee Name	2
3	**Clinical Data**		
3.1		Blood Group	1
3.2		Upload Medical case	2
3.3		Patient Message/Remarks/details about Symptoms	16
4	**Details of Health Insurance**		

4.1		Insurance Company and Health Insurance Policy Number	1
5	**Post Processing Facilitation (Acknowledgement / Confirmation / Cancellation)**		
5.1		Immediate SMS/Phone/email Confirmation of using Online Booking	5
5.2		Appointment Confirmation No	23
5.3		Print Option	2
5.4		Cancellation option	1
6	**Online Security Features**		
6.1		Captcha Code	12

Discussion

A current analysis of the sample hospitals, although some features and functionality come standard with some online appointment systems, most of them vary widely among the many hospitals, provided the 45 ground truth criteria for evaluation and thus classified under six major components such as 1. Pre-Appointment Booking Facilitation 2. Patient Demographics 3. Clinical Data 4. Health Insurance 5. Appointment Post Processing 6. Online Security Features.

G. Pre-Appointment Booking Facilitations

Items classified under this category facilitates the patients or users to easily navigate the hospital website even without their physical presence. One time registration number or access number if generated to the patients, data access and retrieval becomes easy for the hospital personnel. But it is evident from the findings that most of the hospitals do not provide such facility. Major search facilities like search by doctor and speciality are highly considered by most of the hospitals. Choosing appointment date, which forms the most priority facility in an online appointment system is provided by most hospitals, but some hospitals don't have such facility that ultimately don't serve the purpose of the system. Appointment type, Appointment category, doctor's profile and schedule were also given least priority. Alternative choice of appointment date and time are least considered by the hospitals. This inefficiency on part of the hospital online appointment system will lead to indirect waiting time for the patients.

H. Patient Demographics

Information on patient demographics could receive first-hand input which has been ignored by most of the hospitals. The patient demographic information for registration is an integrated patient management system, which captures complete and relevant patient information. Initially, the online appointment system automates the patient administration functions to have better and efficient patient care process. Information on patient email, name, and phone number are highly considered being able to contact you patient is important. Other demographics details as evolved in the ground truth has not been given enough preference.

This lack of information will make patients to spend an extra time in disbursing such details that would affect the quality time spent in the hospital outside of doctor's consultation time.

Clinical Data

In an online appointment booking process, clinical information about the patient will give the doctors time to understand the patient's existing health status before the appointment due that can make face to face interaction more effective. Most of the hospitals are yet to apply this criteria in their online appointment service.

I. Details of Health Insurance

Majority of the hospitals have not considered this criteria in their online appointment services. Health Insurance details of the patients though used only after hospitalisation, it can serve as a guiding tool for hospitals to check if any such insurance plans are restricted from service to the patients. On patients visit to the hospitals, it can be informed to such patients about any inconveniences present in the health insurance. This eases last minute tension on hospital disbursements. Though the details of the health insurance not an important criteria at the time of booking appointments, it may be helpful for information processing of the patient data quickly.

***J.* Post Processing facilitation (Acknowledgement / Confirmation / Cancellation)**

Most hospitals render an appointment confirmation number but immediate SMS/phone/email confirmation is processed by very few hospitals. Other post processing facilitation like print option of the entire details of appointment and cancellation option are yet to be recognised as an important criteria by majority of the hospitals. This suggests that most of the hospitals are not backed by a separate IT department to process the incoming online appointment service.

K. Online Security Features

In compliance with the National Cyber Security Policy of India, 2013, security of online information is mandatory and it also applies to an online booking system. Service providers should incorporate the latest security measures and practices, such as secure server databases, data storage and back-up procedures. For the protection of the patient data, hospitals use a captcha code for patients to enter in the online appointment process. Again, majority of the hospitals do not have such feature.

Overall, patients or users of the online appointment system if facilitated with each of the items classified can obtain easy and less stressful ways to book a doctor appointment. It is noted that most of the hospitals, even among those multi-speciality hospitals that have a high volume of patients walking in offer only a few of the criteria signifying that such hospitals have not updated their online appointment services.

New Model for Online Appointment Booking System Service

The 45 criteria model evolved from the sample hospitals classified under six major components, 1. Pre-Appointment Scheduling Facilitation 2. Patient Demographics 3. Clinical Data 4. Health Insurance 5. Appointment Post Processing 6. Online Security Features will serve as new model and as an entry point to schedule an appointment with the hospital for any types of medical appointment. This proposed model will provide enhanced healthcare by providing timely consultation through instant access to comprehensive patient information.

Effectiveness of the model

A patient centric robust system, this model can be adopted by any hospitals in India and can also be applied to other countries. This model can be used to integrate information across the different department of the hospital for example, data from online appointment services to the Electronic Medical Records (EMRs) for clinical decision making and in computing test results etc. The collection of individual patient information permits the establishment of a longitudinal medical record which is invaluable for improving care of the individual at a lower cost. Application of the model in the hospital's website can enhance patient satisfaction, fewer scheduling errors, reducing no-shows and up-to-date patient information. Effectiveness that can be attained from the perspectives of all the stakeholders are discussed.

L. Hospital's perspective

The extensive patient information as suggested in the evolved model serves as a reference for hospitals to develop related health care systems and enhance the service quality like adding more resources in terms of staffing for IT and other back end operations. Embracing the new model, even government hospitals can become on par in delivering quality services compared to the majority of private hospitals. The private hospitals offering multi-speciality and super-speciality services can add the quality of the online appointment services by including all the criteria in their services. This model covers all problems that arise out of inefficient booking systems in every hospital like that of finding a suitable match among the available time slots of providers in the clinic, provider prescribed restrictions on how available slots may be filled and patients' preferences for day/time of week. Additionally, linking insurers, healthcare providers, government, and patients has the potential to reduce significantly administrative costs in terms of less paper work. Online services through hospital websites will reach patients more quickly as choice of treatment are most of the times, hospital centric as patients will quickly recall the hospital than a doctor or a speciality. Using this model, hospitals could learn how patients rate their organization's service quality through patients' cognition of technology-based service encounters that can further improve their service standard.

M. Doctor's Perspective

Doctors are always impacted by the uncertainty in the number of patient appointments on any given day. The proposed model can reduce this uncertainty. From the perspective of individual doctors, this model helps doctors have an opportunity to review the list of upcoming patients and details about their complaints. Further it reduces the complexity time management as it gives an overview of the number of patients booked thus saving direct communication time for the patient. Above all, by allowing patients to book their own appointments online using this exhaustive model, a new channel of communication can be exploited by both the patient and doctor to better manage their relationship. Since most of the information about the patients are given, doctors can study the patient data much before the actual visiting time, thus making the patients feel more involved. Doctors do not waste time waiting for patients who are late or have forgotten about the visit due to unforeseen coincidence or other reasons. Doctors signed to the system can monitor status of visits of his/her patients.

N. Patients' perspective

With the rise of more informed patients, the model can help patients chose a specialist, location by city or hospital wise or by the set of all these criteria in a hospital. Easy access to a doctor is the first step for patients using health services. When finding a proper specialist patient is able to view all available times of visits and select the most convenient one. One

time information input by the patients can lessen the time spent in the hospitals. Through this model, patients are automatically informed about the upcoming visit time by SMS and signed in to the system they can always cancel the visit. Patients receive text messages reminding about upcoming visit time, informing about time or the availability changes of the visit, besides, patients can also cancel the visit and warn specialists about not showing up.

O. Government Perspective

This proposed model can drive good health care facilities for the citizenry. The aim of the government should be to ease delivery of health care by allowing patient records to be kept in a database and accesses online, which the proposed model will serve as linking tool, especially when the government may want health reports of the people for allocating national identification health number in future as like that of US and Europe. Further this proposed model can be used to study (a) long term studies on health patterns, healthcare trends, lifestyle diseases, chronic illnesses, drug usage (b) short term studies on disease/epidemic outbreaks, control of epidemics, patient response to epidemic control, etc. (c) framing/evolving of new/improved healthcare policies as information about the patients can be made assessable to benefit the entire population.

CONCLUSION

This research work investigated the Online Appointment System Services of hospital websites in India and assessed the quality of the process. The assessment yielded valuable insight into the structure and build-up of the current online appointment systems in hospitals in India. U.S Patent no. 20110313806 on Online Appointment Booking System offered a comprehensive set of suggestive modules in setting up of good online appointment systems in hospitals. The same patent was used as a benchmark to evaluate the existing online appointment models of hospitals in India. The results of this evaluation inspired the evolution of a new exhaustive, comprehensive, efficient online appointment model for hospitals in India, which will serve to provide efficient ICT based healthcare delivery. The proposed new model provides an efficient communication tool that facilitates provisioning of comprehensive healthcare delivery through its various modules. Implementation of this new model will also help to facilitate healthcare delivery through inter-networked hospitals as an outcome of the strengths of the new model.

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Appendix I

List of Hospitals chosen for the study (arranged in order of City, alphabetically)

I. Ahmedabad (Gujarat)

1. The Gujarat Cancer and Research Institute
2. Sterling Hospitals
3. Apollo Hospitals
4. SAL Hospital
5. Shalby Hospitals
6. Care Institute of Medical Sciences
7. HCG Medi-surge Hospital
8. B.J Medical College

II. Bangalore (Karnataka)

1. Narayana Nethralaya
2. M S Ramaiah Memorial
3. Fortis Hospital
4. Columbia Asia Referral Hospital
5. Apollo Hospital
6. St. John's Medical College
7. BGS Global Hospitals
8. Bowring & Lady Curzon Hospital
9. Mallya Hospital
10. National Institute of Mental Health and Neuro Sciences
11. Nethradhama Superspeciality Eye Hospital
12. Narayana Hrudayalaya
13. Sri Jaya Deva Institute of Cardiovascular Sciences and Research
14. Manipal Hospital
15. Kidwai Memorial Institute of Oncology
16. Healthcare Global Enterprises
17. Hosmat Hospital
18. Sparsh Hospital

III. Chandigarh (1)

1. Post Graduate Institute of Medical Education & Research

IV. Chennai (Tamilnadu)

1. Apollo Hospital
2. Billroth Hospital
3. Cancer Institute, Adyar
4. Chetinad Health City
5. Dr. Mehta's Hospital
6. Dr. Mohan's Diabetes Specialities Centre
7. Fortis Malar Hospital
8. Global Hospitals & Health City
9. Government General Hospital
10. M.V. Hospital for Diabetes
11. Madras Mission Hospital
12. MIOT Hospitals
13. Sankara Nethralaya
14. Sri Ramachandra Medical Centre
15. Vasan Eye Care
16. Vijaya Hospital

V. Coimbatore (Tamilnadu)

1. Aravind Eye Hospital
2. G. Kuppusamy Naidu Memorial Hospital
3. Ganga Hospital
4. KG Hospital
5. Kovai Medical Center and Hospital
6. PSG Hospitals
7. Sri Ramakrishna Hospital

VI. Delhi

1. All India Institute of Medical Sciences
2. Batra Hospital & Medical Research Centre
3. BLK Super Speciality Hospital
4. Dr. R.P. Centre for Opthalmic Sciences (AIIMS)
5. Dr. Ram Manohar Lohia Hospital
6. Dr. Sharoff's Charity Eye Hospital
7. Fortis Escorts Heart Institute & Research Centre
8. GB Pant Hospital
9. Indian Spine Injuries Centre
10. Indraprastha Apollo Hospital
11. Max Super Speciality Hospitals
12. Medanta-The Medicity
13. Rajiv Gandhi Cancer Institute & Research Center
14. Sir Ganga Ram Hospital
15. Vidyasagar Institute of Mental Health & Neuro Sciences

VII. Hyderabad (Andhra Pradesh)

1. Apollo Hospitals
2. CARE Hospitals
3. Global Hospitals
4. Kamineni Hospital
5. Krishna Institute of Medical Sciences
6. LV Prasad Eye Institute
7. Medwin Hospitals

8. Nizam's Institute of Medical Sciences
9. Osmania Hospital
10. Rainbow Children's Hospital
11. Yashoda Hospital

VIII. Indore (Madhya Pradesh)

1. Bombay Hospital
2. CHL-Apollo Hospitals
3. Choithram Hospital & Research Centre
4. Gokuldas Hospital
5. Maharaja Yashwantrao Hospital
6. Sri Aurobindo Institute of Medical Sciences & Hospital

IX. Kochi (Kerala)

1. Amrita Institute of Medical Sciences
2. Ernakulam Medical centre
3. Lakeshore Hospital & Research Centre
4. Lisie Hospital
5. Lourdes Hospital
6. Medical Trust Hospital
7. PVS Memorial Hospital

X. Kolkata (West Bengal)

1. Advanced Medicare and Research Institute (AMRI) Hospital
2. Apollo Gleneagles Hospital
3. Belle Vue Clinic
4. Calcutta Medical Research Institute
5. DESUN Hospital & Heart Institute
6. Institute of Post Graduate Medical Education and Research
7. Medical College and Hospital
8. Nil Ratan Sircar Medical College & Hospital
9. Peerless Hospital & B.K. Roy Research Centre
10. Rabindranath Tagore International Institute of Cardiac Sciences

XI. Lucknow (Uttar Pradesh)

1. Mayo Hospital
2. Ram Manohar Lohia Combined Hospital
3. Sahara Hospital
4. Sanjay Gandhi Post graduate Institute of Medical Sciences
5. Vivekanand Hospital

XII. Ludhiana (Punjab)

1. Christian Medical College
2. Dayanand Medical College & Hospital
3. Ludhiana Medicity
4. Satguru Prathap Singh Apollo Hospitals

XIII. Madurai (Tamilnadu)

1. Aravind Eye Hospital

XIV. Mumbai (Maharastra)

2. Asian Heart Hospital
3. Bombay Hospital & Medical Research Centre
4. Breach Candy Hospital
5. Dr. Balabhai Nanavati Hospital
6. Hinduja Hospital (P.D. Hinduja National Hospital & Medical Research Centre)

7. Jaslok Hospital
8. King Edward Memorial Hospital
9. Kokilaben Dhirubhai Ambani Hospital & Medical Research Institute
10. Lilavati Hospital & Research Centre
11. Lokmanya Tilak Municipal General Hospital
12. Sir J.J Group of Hospital
13. Tata Memorial Hospital

XV. Nagpur (Maharastra)

1. CARE Hospital
2. Central India Institute of Medical Sciences
3. Government Medical College and Hospital
4. Orange City Hospital & research Institute
5. Wockhardt Super Speciality Hospital

XVI. Pune (Maharastra)

1. Aditya Birla Memorial Hospital
2. Deenanath Mangeshkar Hospital
3. Jehangir Hospital
4. KEM Hospital
5. Poona Hospital & Research Centre
6. Ruby Hall Clinic
7. Sahyadri Hospital
8. Sancheti Institute for Orthopaedics

XVII. Thiruvananthapuram (Kerala)

1. Ananthapuri Hospitals & Research Institute
2. Cosmopolitan Hospital
3. Government Medical College
4. Kerala Institute of Medical Sciences
5. NIMS Medicity
6. PRS Hospital
7. Regional Cancer Centre
8. Sree Chitra Tirunal Institute for Medical Sciences and Technology
9. Sree Uthradom Thirunal Hospital

XVIII. Vellore (Tamilnadu)

1. Christian Medical College

Appendix II

Determined Sample Population (arranged in alphabetical order)

1. Amrita Institute of Medical Sciences
2. Ananthapuri Hospitals and Research Institute
3. Apollo Hospitals
4. Asian Heart Hospital
5. BLK Hospital
6. Christian Medical College
7. Columbia Hospital
8. Ernakulam Medical centre
9. Fortis Hospitals
10. Global Hospitals
11. Hinduja Hospital
12. Kamineni Hospitals

13. Kerala Institute of Medical Sciences
14. Kokilaben Hospital
15. Krishna Institute of Medical Sciences
16. Lilavati Hospital and Research Centre
17. M.V. Hospital for Diabetes
18. Manipal Hospitals
19. Max Hospitals
20. Mayo Health Center
21. Mehta Hospitals
22. Narayana Hrudalaya Hospitals
23. Nethradhama Hospitals
24. Peerless Hospital
25. Rabindranath Tagore Institute of Cardiac Sciences
26. Sahyadri Hospitals
27. Sancheti Hospital
28. Sankara Nethralaya
29. Shalby Hospitals
30. Sparsh Hospitals
31. The Madras Medical Mission Hospital
32. Yasodha Hospitals

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