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THE IMPORTANCE OF CONCRETE MIX DESIGN (QUALITY CONTROL MEASURE)

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ABSTRACT

This paper covered major aspect of concrete mix design as the quality control measure of concrete production, using American method of concrete mix design procedure. It is aimed at highlighting the important of designed concrete as compared to an ordinary ratio analyzed concrete in concrete production for any civil/structural concrete work. This is to analyze the merit and demerit of designed and control of concrete production as required by BS 8110 in structural requirement. It equally include the whole laboratory test analysis, to determine the physical and geotechnical properties of the materials needed for the mix design in order to attain the required data for the design procedure, in accordance to the parent material types and location, and the specific density of the designed concrete, that will be suitable, adoptable, durable, economical, workable and generally safe for the structural design objective of the weather condition in any specified locality. This is equally aimed at controlling the rate of structural failure in Nigeria as a nation an this regard all factors that may lead to failure of concrete structure were generally treated. The design covered concrete grade 25N/mm^2, 30N/mm^2 and these were designed to attain the required strength grade after 28 days of curing specially with water as the minimum strength. Basically the designs were done with Burham cement as one of the Brand of ordinary Portland cement. It was equally considered as a factor that all the grade of concrete designed for, should achieve 65% strength after been cured for seven days in water. The individual result of the design mix were adequately presented and have shown that generally mix design of concrete before production as measure of quality control of concrete work is very important in any civil project either for Government and individual. Quality control should be applicable, to control structural failure.

INTRODUCTION

For the design requirement of any concrete structured project to be achieved, close supervision of the project and adequate concrete mix design should be by the civil Engineer involved. In recent year we have witness allot of concrete structural failure either during construction, after the completion or few year of the project age of completion, without satisfying design age of the project life.

Consideration of Design

Considering any civil project of your own, that includes the use of concrete for the structural member. It is required that all the materials needed for the concrete should be tested, to determine the physical properties of such materials. These are: Water, Fine Aggregate (Sand), Coarse Aggregate, Cement, Chemicals, Reinforcement and Soil, to determine the bearing capacity of the project location.

The value of the physical properties obtained will be used for as basis of all the design consideration for the concrete mix design. These will assist in preventing failure in the design of general structure and the design concrete mix needed for the structure. If this project is well supervised, the design age of the project will be adequately achieved. It is necessary that in every individual project, there should be a qualified quality control engineer.

Condition of Design

It should be understood; that concrete mix design and concrete production must achieve the specified requirement, and also that the physical properties of materials obtainable might vary from one location to another. It is a common practice to produce a trial concrete mix design in Kaduna State with Kaduna soil rock, water, Brand of cement and weather condition of Kaduna State and decide to use it in Port-Harcourt or Lagos. This will certainly led to structural failure, during the life span of the project, because the nature of occurrence of parent material change from zone to zone, state to state, region to region and country to country**.** Therefore at any location at all, there should be completely different design analysis for the project as it changes from place to place accordingly. If there is an alteration or change in the material location, Brand and replacement as the case be, another or new mix design to ascertaining the physical properties of the alterated or change material be applied on the concrete mix design as may be needed.

Quality Control of Concrete Mix Design

In mix design analysis the consideration of concrete mix design is accepted as trial mix design until it has generally conformed with the required specifications needed for the check and balance, by the civil engineer as the quality control personnel and approved, by representative of the client before site application as new mix design. All the materials for concrete have their specific code of practice to access the physical properties of the material these are

1. Water: BS 3148
2. Aggregate: BS 812 (1975, 1989-1995)
3. Cement: - BS 4550 parts, 1978
4. Concrete: BS1881
5. Reinforcement: BS 4449, 5400 part (1999)
6. Soil Analysis:- BS 1377, (1990)

The codes of practice serve as bases for checks and balances of all the material physical and geotechnical performance. In order word Quality Control Personnels duty is to make sure that the Design Strength of Concrete is equal to the required strength as the minimum strength quality control consideration for safety, Durability, Rigidity economy, and aesthetics during the design analysis, in order to achieve serviceability requirement.

Major Factors Affecting Concrete Mix Design as Measure of Quality Control Procedure

According to BS 812 (1975, 1989-1995), BS1881 the design of concrete should be on the following:

1. Grade designation
2. Choice of Cement
3. Choice of Aggregate size
4. Types of water
5. Choice of Water to cement ratio
6. Workability
7. Durability

Grade Designation: Every grade of concrete has it's strength in N/mm^2 when subject to test after Twenty eight days of curing in any curing medium, which could be water, sand with water, jut bags with water and other curing fluid. The choice of concrete grade, depend on the types of member to be casted or used for. Every concrete has its purpose of usage as follows:

Table 1: Concrete Grade and Usage

Concrete Grade N/mm^2	Ratio Cement, Sand Aggregate	Usage
10	1:4:8	Blinding Concrete
15	1:3:6	Mass Concrete
20	1:2.5:5	Light Reinforce Concrete
25	1:2:4	Reinforce Concrete
30	1:1.5:3	Heavy Reinforced Concrete Pre-cast
35	1:1.5:2	Pre-stress Concrete/Pre-cast
40	1:1:1	Very Heavy Reinforced Concrete Pre-Stress /Pre-cast

The above concrete grade ratios can be re-organized as a trial mix design to achieved the design strength based on the availability of material in that locality. Most Concrete ratios were rated in kilogram by weight and concreted to the equivalent proportion by volume.

Choice of Cement: Locally we all know that Ordinary Portland Cement (OPC) are the most available in the market for building structure are the most adoptable for Trial Mix Design for super structures. For Marine Structures Sulphat Resistance (SRPC) and Rapid Hardening Portland Cement (RHPC) are most adopted for trail mix design. For normal water logged area structures, sulphate resistance Portland cement is needed for Trial Mix Design. They should be subjected to physical test analysis to ascertaining their performance as required by the codes, BS4550 and B.S12, BS4027 respectively, before application to design mix analysis.

Choice of Aggregate Size: It is not all aggregate that is suitable for concrete. Some aggregate may contain certain minerals that are harmful and some may not have the required physical properties needed for concrete design limitation, some may have high silt and clay content, at high percentage which are not allow in concrete. To control all this, aggregates, both fine and coarse must be quality sized before usage in accordance with the BS Standard required.

Types of Water: Any water at all, to be use for concrete work, should be subjected to test and must be within the range of water required for concrete, before used. Mostly, all consumable water is adequate for concrete work, as specified by BS 3148. Most of the water limitations are presented in the Appendix B.

Water to Cement Ratio: This is the ratio of water to cement, in achieving the required consistence, initial setting, final setting and soundness of the specified cement in relationship to the workability, compacting factor, and slump of the designed concrete, to achieve the desired objective. This is subject to cement test and concrete trial mix design analysis.

Workability: This is the measure of ease of mixing concrete without difficulty segregation and bleeding. Workability mostly depend on the designed slump of concrete as selected from specified chart recommended for the design mix, as shown in Appendix B.

Durability: This is the measure of the required strength inN/mm^2 of any concrete grade after twenty eight days (28) of intensive curing of the concrete as a representative of the design age and strength of the concrete life span. This is always achieved after the trail mix design of the required grade of concrete. The control test analysis is also carried out during the application of the design concrete mix to ascertain the required strength on site, for safety, durability and economy of the structure.

Methods of Concrete Mix Design

1. Minimum void method
2. Water-cement ratio method
3. Maximum density method
4. **American method of mix design**
5. Fineness modulus method
6. Standard deviation method
7. Arbitrary Method
8. Graphic or Road not method
9. Indian Road Congress IRC - 44 method
10. Mix design base on flexural strength
11. ACI committee 211-(1991) method
12. Department of Environment (DOE) mix design method
13. Indian standard recommended (IS CO262) – 1992/method

For this Technical paper let us examine the American method of mix design that is based on unified density of the available materials at any project location. The American method of mix design deals with raw data from the physical property of the material around the project location, which is utilized in the design to the required real density of concrete, as the maximum density obtained when using such material for concrete in that specified location.

American Method of Mix Design: Entail the following steps.

1. Obtain all the individual materials example, water, cement, sand and coarse Aggregate including chemical if needed.
2. Subjecting the individual material to physical and geotechnical test analysis, example water test, cement test, Aggregate sieve analysis specific densities, finest modules, flakness and elongation index aggregate impact value test (AIV) and aggregate crushing value (ACV) test as shown in Appendix C
3. Subjecting the result of the Analysis to the design procedure in conformity with the specified tables and chart.
4. Choice of concrete needed to be designed for with a specific uses and types of concrete will be selected.
5. Based on the selected types of concrete, recommended table and chart are available for definite limit and selection of value for the design procedure as show in appendix A.
6. Determination of the theoretical density is the end product of mix design calculation in kg/m^3.
7. Re-ratio of the theoretical density using the minimum value. Analysis as guided by general specification of the Federal Ministry of Works and House, Road and Bridge volume II for economic reasons will be adopted as shown in Appendix B.
8. Running the trial mix design of the concrete density to obtain the required result for 7 days and 28 days strength of the curing concrete. This will serve as the control result for approval, before application of the design on site.
9. Quality control of the batching by weight is equally, consistently done, to guide and control concrete application on site as the in order to correct any form of mistake during casting period on construction site.

The above steps are to be adhered to in order to avoid failure of concrete structure in our locality and Nigeria at large.

The Relationship between Design and Construction

The design and construction of a structure are closely related. In the current practice, a facility (e.g a building) is conceived (designed) in computer files and graphics by applying the provisions of codes and standards, and physically created (constructed) at the site using these files and graphics. A design is successful if it can be constructed for use at the site.

The safety, strength, serviceability, and durability stipulated in a design can be achieved through good workmanship and quality control at a construction site. Good workmanship and quality control, on the other hand, are possible only if specifications are clearly defined, and connection (inter-connectivity) details are simple and executable at the site (Fig 2.2 show the relationship).

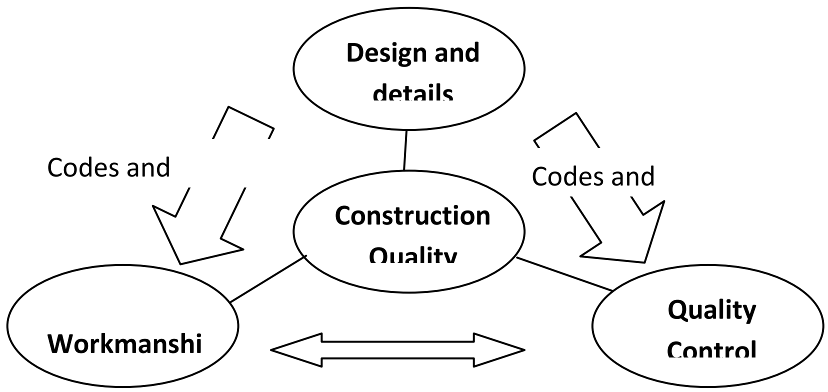

Figure 2.2 Relationship between design and construction

Responsibilities for Quality Construction

The client, design consultant, and contractor must work as a team to achieve the desired quality in RC construction. Figure 2.3 highlights the major task for the three parties in the relationship needed for the successful completion of a building project with the desired quality level.

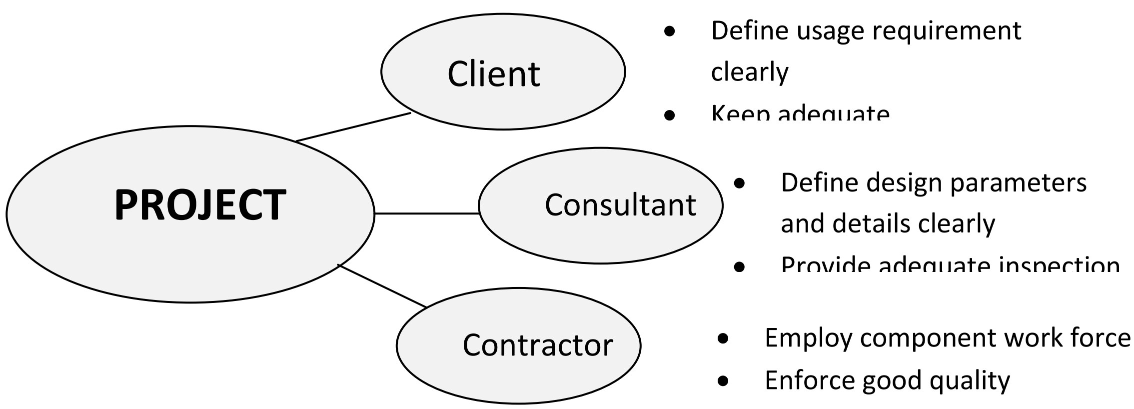

Figure 2.3: Responsibilities of the client, consultant, and contractor.

A Sample Mix Design

Let us examine the following mix design example. A new bridge is to be constructed at Dammani boundary to link Rigasa and Dan mani town in Igabi Local Government Area of Kaduna State. Using America method of concrete mix design procedure, with Burham cement, tap water, sharp sand from River Kaduna and Crashed aggregate from Eksiogullari Quary run a trial mix design of concrete grade 25N/mm^2 and 30N/mm^2, if the following data were achieved, determine the initial densities and provide mix design for the above grade of concrete. Achieved Data: concrete grade 25N/mm^2 and 30N/mm^2

Concrete slump = (30-80)mm
Specific gravity of agg (coarse) 2.567
Specific gravity of Agg (fine) 2.549
Finess module of Agg (fine = 2.705

For the solution of these problems, the procedure are, as presented in the format below; in format 1, format 2 and form 1, with format 3, 4 and form 2 for concrete grade 25 and 30 as required, as presented in Appendix A. The individual charts used during the design procedure were provided in appendix A. Most of the test analyses listed above about the concrete properties were illustrated in appendix C.

Major Course of Concrete failure

1. Lack of project supervision
2. Lack of Design mix in concrete production
3. Lack of Quality Control as part of Project executions
4. Lack of Skill Professional at the Project Site.
5. Wrong award of Contract to non Professional
6. Lack of awareness on Design Specification and General Pacification to the Masses
7. Corruption on part of Construction personnel, Consultant and stake holders.
8. Illiteracy on the part of client and contractor
9. Absence of Consultant in most projects.

CONCLUSION

Based on the illustration of the concrete mix design of the required grade above, it is clear that the concrete density achieve were 2300kg/m^3 of grade 25N/mm^2 and 30N/mm^2 as the true density of the combine material, with their definite ratio of water, as fresh concrete and have yielded better and required result at 7 days of curing age in water and twenty eight days of curing age in water. Since the strength obtained were greater than the requirement strength, the design is considered adequate for the bridge concrete work.

Graphical explanation

It is clearly that fine aggregate sieve Analysis were achieved within zone 2 in fig 2.8. For coarse aggregate all Falls within their specific envelop. As in fig 2.6 and 2.7. For concrete graph analysis with Strength and crushing age it clear that both G30 and G25 achieve their Maximum strength of concrete as required by B.S 1881as in fig2.4 and 2.5.appendix A.

RECOMMENDATION

- In case of any civil structure on concrete project the procedure above should be strictly followed for other lower grade and high grade of concrete mix design and application

- Project should not be awarded to non professionals in order to control or reduce structural failure.
- All civil oriented project, should be duly executed with design and control procedures in order to achieve the design objective and serviceability of the project
- All individual project concerning concrete work, should be designed for and control by an experience quality control engineer.
- The environmental protection and development authority should include quality control as part of the requirements for the approval of project for private, state and federal project.
- There should be public awareness about the important of quality control in all sector of production and construction industries and to the individuals in order to control or reduce failure.

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Neville, A. M. (1983): Properties of Concrete . 3rd Edition. Published by: Ptiman Books Limited.

Federal Ministry of Works and Housing (1997): General Specifications, Road and Bridges Vol 2.

CBM –CI International Workshop, Karachi Pakistan By Dr. K. Mahmood

APPENDIX A:
Fermat 1:

CONCRETE DENSITY MIX DESIGN			
Date	20 05 2010	Operator	**Engr. Salihu Andaa Yunusa**

Uses:	Reinforced concrete Structure
The aspire strength required G25	$30Nmm^2$
The slum (maximum)	(30mm-80mm)
Maximum size of Aggregate ¾ "	19mm
Bulk density of Aggregate	$1710Kg/m^3$
Specific gravity of Aggregate	2.567
Finess modulus of fine Aggregate	2.705
Specific gravity of Fine Aggregate	2,549
Water Requirements (Table 10.16 (a) and 10.16 (b))	$\frac{200x92}{100} = 184Kg/m^3$
Standard Specific gravity of Cement	3.15
The entrapped air content	2%
Water Cement Ratio (Table 10.8 (a)) and (b)	0.55
Hence, the cement content	$\frac{184}{0.5} = 335Kg/m^3$
Bulk Volume of Coarse Aggregate per unit volume of concrete (Table 10.17-10.18)	0.63
Hence, the weight of Coarse Aggregate per cubic meter of concrete	1710x0.63 = 1077Kg
The Absolute volume of mix ingredient per cubic meter of concrete are:-	
Cement	$\frac{335}{3.15x1000} = 0.106m^3$
Water	$\frac{184}{1000} = 0.18m^3$
Coarse Aggregate	$\frac{1077}{2.567x1000} = 0.420m^3$
Entrapped Air	$1 x 0.02 = 0.020m^3$
Total Volume	$0.73m^3$
Hence the volume of Fine Aggregate required	$1 - 0.73m^3 = 0.27m^3$
The corresponding weight	0.270 x 2.549 x 1000 = 688kg
Plastiment BV 40	$\frac{1}{100} x \frac{335}{1} = 3.4kg$
The weight of material per cubic meter of concrete are:	
Cement	335Kg
Water	184Kg
Fine	688Kg
Coarse	1077Kg
BV 40	4Kg
Total	2288Kg
Hence, the density of concrete	$2300Kg/m^3$

APPENDIX A CONCRETE MIX DESIGN SHEET
Format 2:

Construction site:					**Date**		**35/05/2010**	
Construction Section		Reinforced			Mixing plant:			
Concrete Class/grade		G25			Water Cement Ratio:		0.55	
Density		2300Kg/m^3			Compacting Factor		0.94	
Ratio	1:2:4	Burham Cement			Slumps (mm)		35	
Mix for	1m^3				0.5m^3			
Cement	Ordinary mix kg	Head Pan Heaped	Additive Mix Kg	Head Pan Heaped	Ordinary Mix Kg	Head Pan Heaped	Additive Mix Kg	Head Pan Heaped
	305	12	305	12	153	6	153	6
Sand (Sharp)	608	24	608	24	304	12	304	12
Aggregate (4 to 16 mm)	427	13	427	13	214	6.5	214	6.5
Aggregate (16 to 20mm)	792	23	792	23	396	11.5	396	11.5
Water	168	Bkt 9	166	Bkt 8.5	84	Bkt 4.5	83	Bkt 4
Plastiment BV 40	-		2	2liters	-	-	1	1 liter
Total	2300kg/m^3			2300 kg/m^3	1151 kg/m^3			1151 kg/m^3

APPENDIX A

BURHAM CEMENT 2300				**COMPRESSIVE TEST CONCRETE**						**DATE**	**25/5/2010**	
				GRADE	**25N/mm²**			**W/C RATIO**		**LOCATION**	**LABORATORY OFFICE**	
PLACING DETAIL				**SLUMPS 35MM**						**COMPACTION FACTOR**		
Cube & Identification marks	**Size of specimen**	**Date of cast**	**Age for testing (days)**	**Date tested**	**Curing**	**Weight of Cube (g/cm^3)**	**Types of fracture slump**	**Density of cube (g/cm^3)**	**Mix proportion**	**Crushing load KN**	**Crushing strength (N/mm^2)**	**Remarks strength required N//mm²**
439	15x15x15	25/05/2010	7 Days	31/05/2010	IMMERSION IN WATER	8227	True	2.44	1:2:4	540	24.0	
440	"	25/05/2010	"	"		8309	True	2.46	1:2:4	416	18.5	
441	"	25/05/2010	"	"		8245	True	2.44	1:2:4	442	19.6	
Average:											20.7	16
442	15x15x15	25/05/2010	28 Days	22/06/2010		8309	True	2.46	1:2:4	800	35.5	
443	"	25/05/2010	"	22/06/2010		8309	True	2.46	1:2:4	700	31.1	
444	"	25/05/2010	"	22/06/2010		8309	True	2.46	1:2:4	750	33.3	
Average											33.3	25

CONCRETE LABORATORY COMPRESSIVE STRENGTH TEST

Form 1:

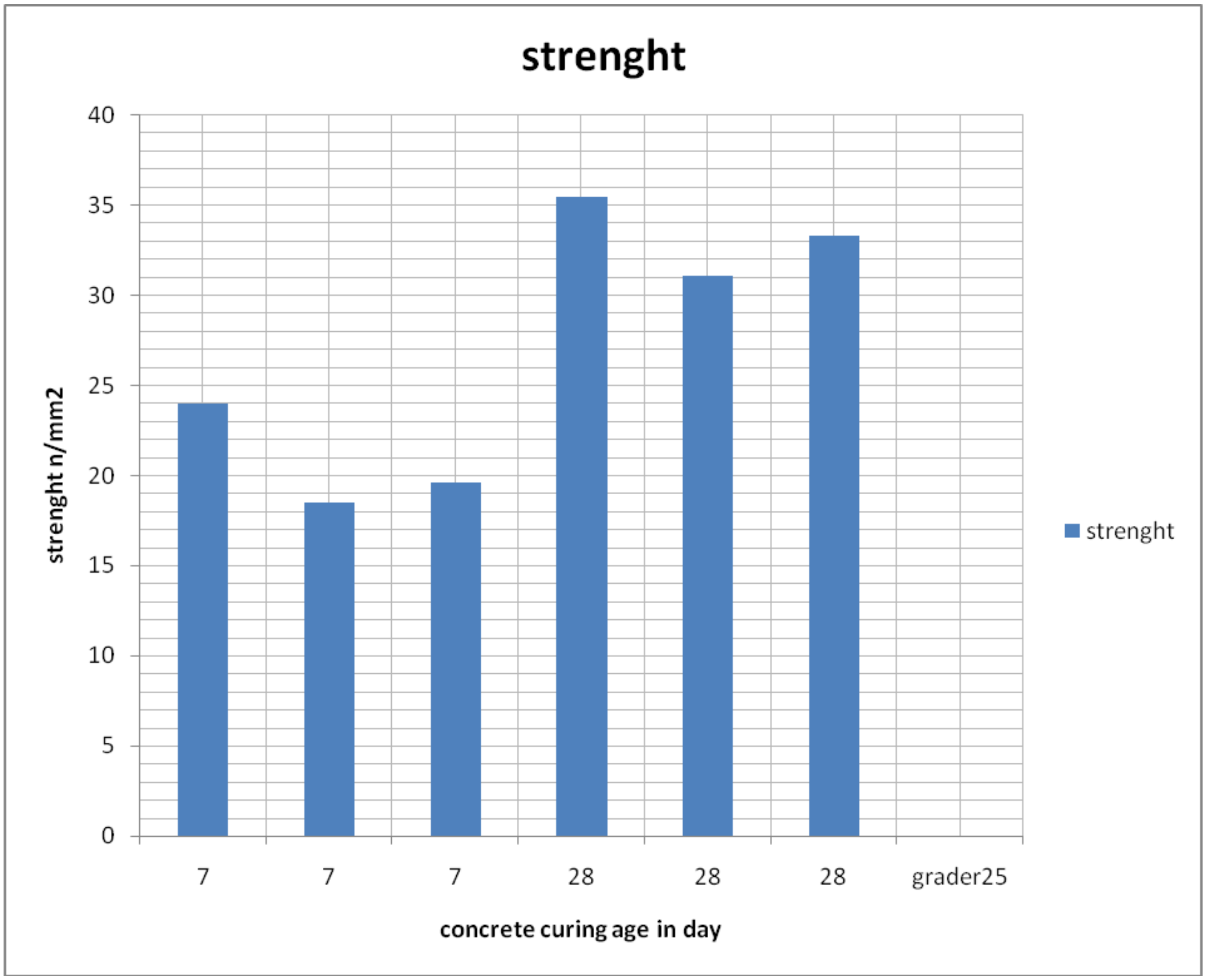

Fig 2.4

APPENDIX A
Format: B

CONCRETE DENSITY MIX DESIGN			
Date	20 05 2010	Operator	**Engr. Salihu Andaa Yunusa**
Uses:			Reinforced concrete Structure
The aspire strength required G30			35Nmm^2
The slum (maximum)			(30mm -80mm
Maximum size of Aggregate ¾ "			19mm
Bulk density of Aggregate			1710Kg/m^3
Specific gravity of Aggregate			2.567
Finess modulus of fine Aggregate			2.705
Specific gravity of Fine Aggregate			2,549
Water Requirements (Table 10.16 (a) and 10.16 (b)) and 10.16 (b)			$\frac{200x92}{100}$ = 184Kg/m^3
Standard Specific gravity of Cement			3.15

The entrapped air content	2%
Water Cement Ratio (Table 10.8 (a))	0.50
Hence, the cement content	$\frac{184}{0.5}$ = 368Kg/m^3
Bulk Volume of Coarse Aggregate per unit volume of concrete (Table 10.17-10.18)	0.63
Hence, the weight of Coarse Aggregate per cubic meter of concrete	1710x0.63 = 1077Kg
The Absolute volume of mix ingredient per cubic meter of concrete are:-	
Cement	$\frac{368}{3.15x1000}$ = 0.117m^3
Water	$\frac{18}{1000}$ = 0.18m^3
Coarse Aggregate	$\frac{1077}{2.567x1000}$ = 0.420m^3
Entrapped Air	0.02 x1 = 0.020m^3
Total Volume	0.741m^3
Hence the volume of Fine Aggregate required	1 – 0.741m^3 = 0259m^3
The corresponding weight	0.259 x 2.259 x 1000 = 660kg
Plastiment BV 40	$\frac{1}{100}$ x $\frac{368}{1}$ = 3.7 = 4Kg
The weight of material per cubic meter of concrete are:	
Cement	368Kg
Water	184Kg
Fine	660Kg
Coarse	1077Kg
BV 40	4Kg
Total	2293Kg/m^3
Hence, the density of concrete	2300Kg/m^3

APPENDIX A CONCRETE MIX DESIGN SHEET
Format 4:

Construction site:			Date					26/05/2010
Construction Section		Reinforced Concrete	Mixing plant:					
Concrete Class/grade		G30	Water Cement Ratio:					0.55
Density		2300Kg/M^3	Compacting Factor					0.95
Ratio	1:2:3		Burham Cement			Slumps (mm)		50
Mix for	1m^3				0.5m^3			
Cement	Ordinary mix kg	Head pan Heaped	Additive Mix Kg	Head pan Heaped	Ordinary Mix Kg	Head pan Heaped	Additive Mix Kg	Head pan Heaped
	350	14	350	14	175	7	175	7
Sand (Sharp)	702	28	702	28	351	14	351	14

Aggregate (4 to 16 mm)	369	12	369	12	185	6	185	6
Aggregate (16 to 20mm)	686	20	686	20	343	10	343	10
Water	193	Bkt 10	191	Bkt 9.5	97	5	96	4.5
Plastiment BV 40	-	-	2	2lters	-	-	1	1 liter
Total	2300kg/m^3		2300kg/m^3				1151kg/m^3	1151kg/m^2

APPENDIX A: Form 3 CONCRETE LABORATORY COMPRESSIVE STRENGTH TEST

BURHAM CEMENT 2300				**COMPRESSIVE TEST CONCRETE**					**DATE**		**25/5/2010**	
PLACING DETAIL				**GRADE**	**30N/mm^2**		**W/C RATIO**		**LOCATION**		**LABORATORY OFFICE**	
				SLUMPS 50MM					**COMPACTION FACTOR**			
Cube & Identification marks	**Size of specimen**	**Date of cast**	**Age for testing (days)**	**Date tested**	**Curing**	**Weight of Cube (g/cm^3)**	**Types of fracture slump**	**Density of cube (g/cm^3)**	**Mix proportion**	**Crushing load**	**Crushing strength (N/mm^2)**	**Remarks strength required N//mm^2**
445	15x15x15	26/05/2010	7 Days	1/06/2010	IMMERSION IN WATER	8122	True	2.41	1:2:3	572	25.4	
446	"	26/05/2010	"	"		8183	True	2.42	1:2:3	612	27.2	
446	"	26/05/2010	"	"		8088	True	2.40	1:2:3	522	25.4	
Average:								2.41			26.0	20
448	15x15x15	26/05/2010	28 Days	22/06/2010		8183	True	2.42	1:2:3	788	35.0	
449	"	26/05/2010	"	22/06/2010		8183	True	2.42	1:2:3	820	36.4	
450	"	26/05/2010	"	22/06/2010		8183	True	2.42	1:2:3	840	37.3	
Average											36.4	30

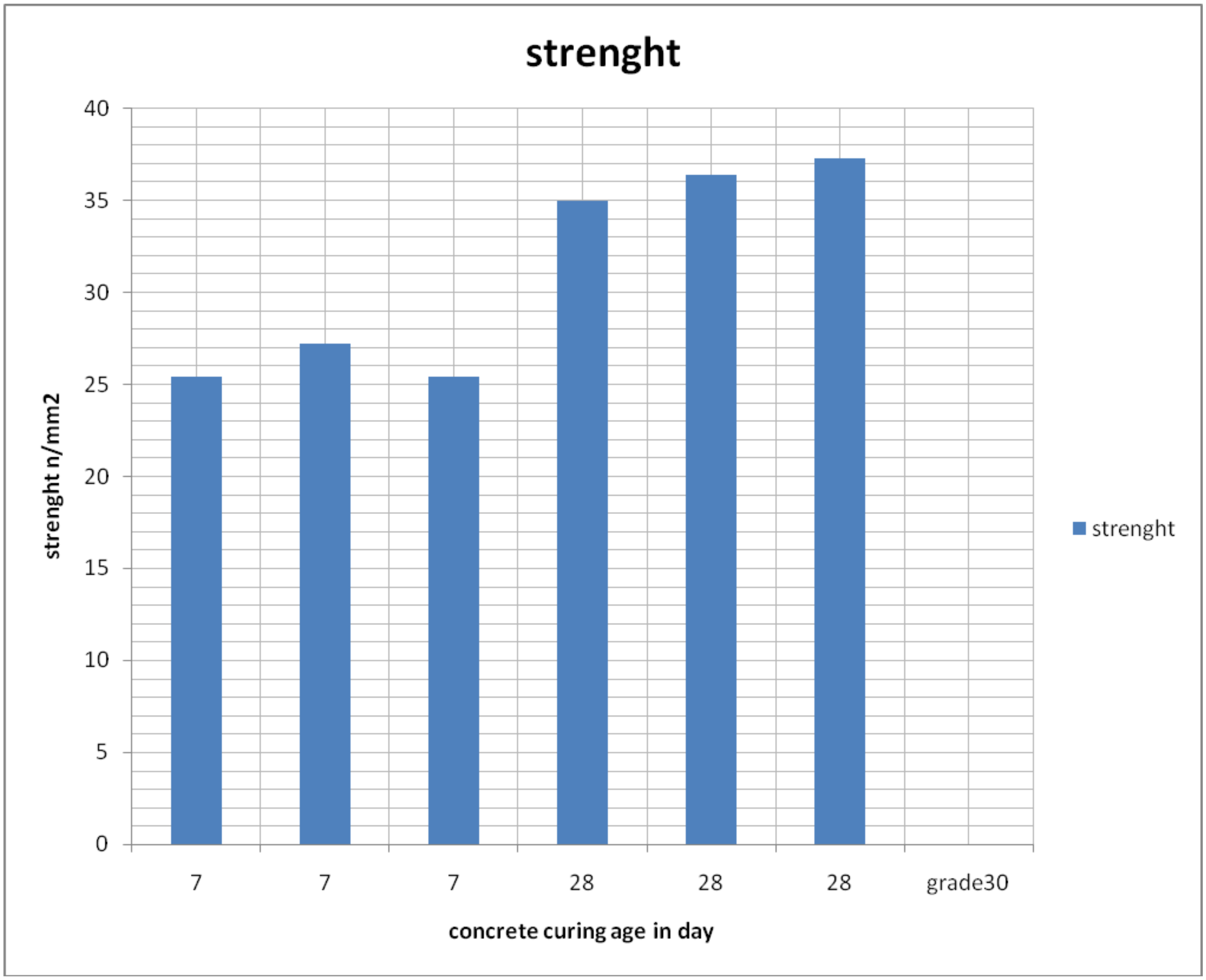
strenght
40
35
30
25
20
15
10
5
0
strenght n/mm2
7
7
7
28
28
28
grade30
concrete curing age in day
strenght

Fig 2.5

onstruction of Kaduna Eastern By-pass Road (with Spur to Rabah Road)
Contract No. 5346

MEASUREMENT PROCEDURE AS CALIBRATED		
MATERIAL DESCRIPTION	**1 HEAD PAN TRIMMED**	**1 HEAD PAN HEAPED**
Sand	18.664Kg	24.983Kg
$^{0}/_{5}$	23.180kg	37.260kg
Aggregate $^{1}/_{2}$"	22.812Kg	31.172Kg
Aggregate $^{3}/_{4}$"	23.946Kg	34.007Kg
Cement	19.229Kg	24.698Kg
Water	15.918Kg	-
Aggregate $^{3}/_{8}$"	24.545Kg	-
1 Wheel barrow of any material.	4 Head Pan trimmed 95.240kg	3 Head pan heaped 111.780kg
Water Bucket	(34 base) water 19.619 Kg	-

Performed and calculated by	Reviewed and checked by	Witnessed by

APPENDIX B

Table (a) Comparison of Workability Measurement

SLUMP	V B TIME (MM)	COMPACTING (SECONDS)	FACTOR
1	0	Over 20	0.65-0.75
2	0-10	20-12	0.75-0.85
3	10-30	12-6	0.85-0.90
4	30-60	6-3	0.90-0.93
5	60-180	3-0	Over 0.93

Table (B) The used of different Degrees of Workability

Degrees of Workability	Slump (mm)	Compacting Factor	Use of Concrete
Very low	0-30	0.78	Road, Mass Concrete Foundation
Low	30-80	0.85	Without vibration of light reinforced sections with vibration
Medium	80-100	0.92	Nominal reinforced concrete manually compacted heavily reinforced section with vibration
High	100-175	0.95	For section with congested reinforcement. Not normally suitable for vibration

APPENDIX B

TEST RESULT ON EKSIOGULLATRI AGGREGATE

AGGREGATE SIZE	BULK DENSITY	SPECIFIC GRAVITY
3/4"	1.71	2.567
1/2"	1.589	2.549
3/8" - Dust	1.466	2.631
River sand	1.447	2.595
sand clay content	1.50%	
sand silt content	98.50%	

AGGREGATE SIZE	FLAKINESS INDEX	ELONGATION INDEX
3/4"	22.90%	25%
1/2"	18%	24.00%

TEST RESULT ON EKSIO QUARY AGGREGATE AS AT 1ST FEB 2010

specific gravity of burham cement	3.15
finess modulus of fine aggregate	2.705
aggregate crushing value	24.78%
aggregate inpact value	13%

	AGGREGATE CRUSHING VALUE
3/4"	26%

Nate:

The experiment is performed
on aggregate passing sieve 14.5mm
and retained on 10mm

APPENDIX B

A.M Neville Factor in the Choice of Mix Proportion (page 667)

Format (10.8a): Relation between Water/Cement Ratio and Compressive Strength of Concrete According to ACI Standard 211.3 -72[10.22]

N/mm^2	psi	Non-air entrained concrete	Air-entrained concrete
48	7000	0.33	-
41	6000	0.41	0.32
34	5000	0.48	0.40
28	4000	0.57	0.48
21	3000	0.68	0.59
14	2000	0.82	0.74

Measured on standard cylinders. The values given are for maximum size of aggregate of 20 to 25 mm (1 to 1 in).

(3000 psi) is laid down together with air entrainment. The German approach is broadly similar. The British Code of Practice for the Structural Use of Concrete CP 10. 1972 gives the minimum cement content for various conditions of exposure and also the minimum cement content and maximum

A.M Neville

Table (10.8b): Maximum permissible water/Cement Ratios for Different Types of structures in Severe Exposure, Prescribed by ACI Standard 211.177[10.2]. Page 667

Types of Structure	Exposure conditions	
	Structure wet continuously or frequently and exposed to freezing and thawing	Structure exposed to sea water or sulphates
Thin section, such as railings kerbs, sills, ledges, ornamental work, and section with less than 25mm (1in) cover to reinforcement	0.45	0.40+
All other structure	0.50	0.45

Air entrained concrete should be used under all condition involving severe exposure. When type II V cement is used, maximum water/cement ratio may be increased by 0.05.
A.M Neville

Table (10.16a): Relative Mixing water requirements for Different Consistencies Concrete[10.22]. Page 698

Description	**Consistence**				**Relative water Content**
	Slump Mm	**in**	**Vebe S**	**Compacting factor**	**Percent**
Extremely dry	-	-	32-18	-	78
Very stiff	-	-	18-10	0.70	83
Stiff	0.30	0-1	10-5	0.75	88
Stiff plastic	30-80	1-3	5-3	0.85	92
Plastic (reference)	80-130	3-5	3-0	0.91	100
Fluid	130-180	5-7	-	0.95	106

APPENDIX B

A M. Neville

Table (10.16b): Approximate Mixing Water Content for the Reference (Plastic) Mix of Table 10.16 (a) For Different Maximum Size of Aggregate[10.2, 10.22]. Page 699

Maximum size of Aggregate		**Non-entrained water content**		**Entrapped air content**	**Air –entrained water content**	
Mm	In	$Kg/.m^3$	Ib/yd^3	Percent	Kg/m^3	Ib/yd^3
10	$^{13}/_{8}$	225	235	3	200	340
12.5	½	215	365	2.5	190	325
20	¾	200	340	2	180	205
25	1	195	325	2.5	175	295
40	1½	175	300	1	160	275
50+	2	170	285	0.5	155	265
70+	3	160	265	0.3	150	250
150+	6	140	230	0.2	135	220

+ water contents of concretes with aggregate sizes greater than 40mm are not given for mixes with a slump of less than 30mm (1.in).

A.M Neville

Table (10.17): Bulk Volume of Coarse Aggregate per Unit Volume of Concrete Page 700

Maximum size of aggregate		Bulk volume of rodded coarse aggregate per unit volume of concrete for fineness modulus of sand of			
Mm	In	2.40	2.60	2.80	3.00
10	$^{13}/_{8}$	0.50	0.48	0.46	0.44
12.5	½	0.59	0.57	0.55	0.53
20	¾	0.66	0.64	0.62	0.60
25	1	0.71	0.69	0.67	0.65
40	1½	0.75	0.73	0.71	0.69
50+	2	0.78	0.76	0.74	0.72
70+	3	0.82	0.80	0.78	0.76
150+	6	0.87	0.85	0.83	0.81

The values given will produce a mix with a workability suitable for reinforced concrete construction. For less workable concrete e.g that used in road construction, the value may be increased by about 10 percent. For more workable concrete, such as may be required for placing by pumping , the values may be reduced by up to percent.

Table (10.18) Factors to be Applied to the Volume of Coarse Aggregate Calculated on the Basis for Mixes of Consistence other than Plastics Page 700

	Factor for maximum size of aggregate of				
Consistence	**10mm (½ in.)**	**12.5mm (½ in.)**	**20mm (¾ in.)**	**25mm (1 in.)**	**40mm (1 ½ in.)**
Extremely dry	1.90	1.70	1.45	1.40	1.30
Very stiff	1.60	1.45	1.30	1.25	1.25
Stiff	1.35	1.30	1.15	1.25	1.20
Stiff plastic	1.08	1.06	1.04	1.06	1.09
Plastic (reference)	1.00	1.00	1.00	1.00	1.00
Fluid	0.97	0.98	1.00	1.00	1.00

APPENDIX B
TABLE 11 – 3 REQUIREMENTS FOR CONCRETE FOR STRUCTURE AND GENERAL CONSTRUCTION

1	2	3	4	5	6	7	7
Purpose	Grade of Concrete	Maximum Size of Aggregate Mm	Minimum Cement Content Per m^3 of Finished Concrete Work Ig	Water Cement Ratio	Work test Minimum Compressive Strength N/mm^2		
					7 days	28 days	
Prestressed Concrete	50 45	20 20	500 450	0.35-0.45 0.35 – 0.45	40 35	50 45	Repid hardening Portland Cement
-do-	40	20	450	0.35-0.45	30	40	
-do-	35	20	400	0.45-055	25	35	
Reinforced Concrete	30	20	350	0.45-0.55	20	30	Ordinary Portland Cement
-do-	25	20	295	0.45-0.55	15	25	
-do-	20	20	235	0.45-0.55	12	20	
-do-	15	20	205	0.55-0.65	10	15	
Mass Concrete	12	40	175	0.55 – 0.65	7	10	
Blinding concrete	10	40	150	0.65-0.75	7	10	

APPENDIX C: SIEVE ANALYSIS+

Date of Test	**20/02/2010**		**N.M.C**		
Construction Site	**Kaduna**		**Sample No.**	**2**	
Equivalent Weight			**Sample Location**	**Eksio**	
Total Weight of Sample	**1800(g)**		**Sample Description**		**¾"**
Sieve No.	**Sieve Size (mm)**	**Weight Retained (g)**	**% Retained**	**% Weight Passing**	**20mm (3/4)% by weight envelop**
1″	25.4mm	-	-	-	10.0
¾″	20.0mm	40	7.8	92.2	85.100
½″	12.5mm	-	-	-	-
$^{3}/_{8}$"	10.0mm	1570	872	5	0-25
$^{3}/_{16}$″	5.0mm	88	4.8	0.2	0-5
No.7	2.36mm				-
No.14	1.18mm				-
No.25	600µm				-
No. 36	425µm				-
No. 52	300µm				-
No.100	150µm				-
No. 200	75µm				-
Passing 200					
Total					-
Remark					

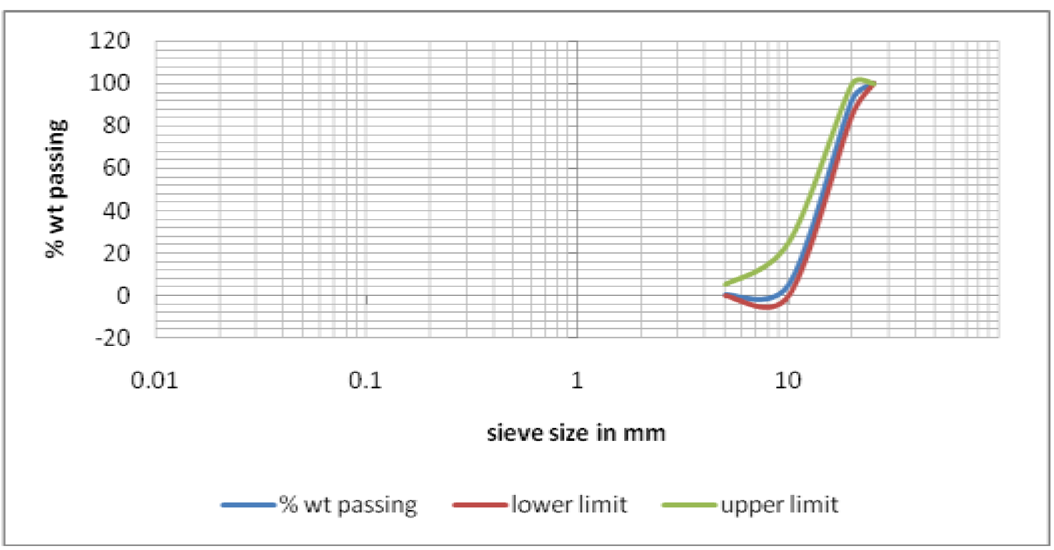

Fig 2.6

APPENDIX C
SIEVE ANALYSIS

Date of Test	**20/04/2010**		**N.M.C**		
Construction Site	**Kaduna**		**Sample No.**	**2**	
Equivalent Weight			**Sample Location**	**Eksio**	
Total Weight of Sample	**1800(g)**		**Sample Description**		**½"**
Sieve No.	**Sieve Size (mm)**	**Weight Retained (g)**	**% Retained**	**% Weight Passing**	**12.5mm (½)% by weight envelop**
1"	25.4mm	-	-	-	-
¾"	20.0mm				100
½"	12.5mm	108	7.03	93.0	85-100
$^{3}/_{8}$"	10.0mm	698	45.4	47.6	0-50
$^{3}/_{16}$"	5.0mm	729	47.5	0.1	0-10
No.7	2.36mm				-
No.14	1.18mm				-
No.25	600µm				-
No. 36	425µm				-
No. 52	300µm				-
No.100	150µm				-
No. 200	75µm				-
Passing 200					-
Total					
Remark					

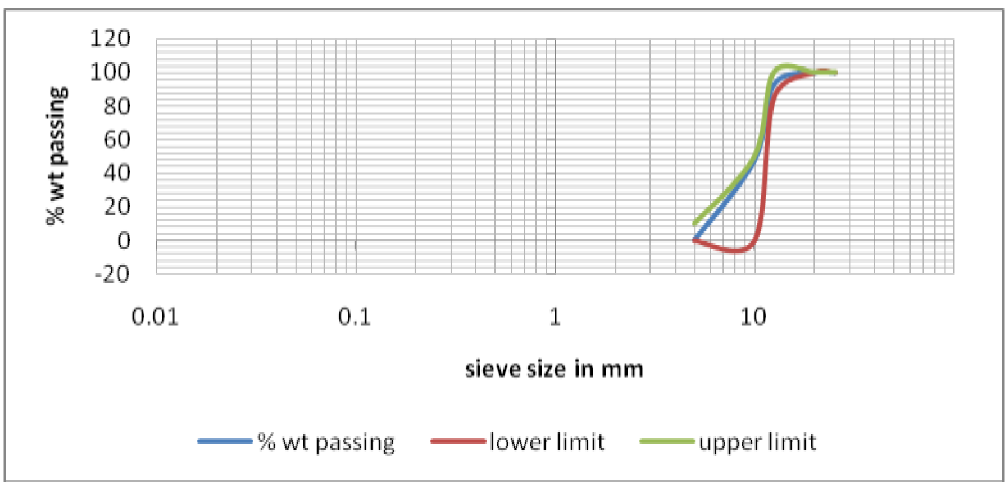

Fig 2.7

APPENDIX C: SIEVE ANALYSIS

Date of Test	**20/04/2010**		**N.M.C**			
Construction Site	**Kaduna**		**Sample No.**		**3**	
Equivalent Weight			**Sample Location**		**Chikaji River Kaduna**	
Total Weight of Sample	**1800(g)**		**Sample Description**		**Fine Aggregate**	**Zone 2**
Sieve No.	**Sieve Size (mm)**	**Weight Retained (g)**	**% Retained**	**Cumulative % Retained**	**% Passing**	**Specification**
1″	25.4mm					
¾″	20.0mm					
½″	12.5mm					
$^3/_8$"	10.0mm	-	-	-	100	100
$^3/_{16}$″	5.0mm	61	9.9	9.9	90.1	90.100
No.7	2.36mm	41	6.7	16.6	83.4	75-100
No.14	1.18mm	100	16.2	32.8	67.2	55-90
No.25	600µm	72	11.7	44.5	55.5	35-59
No. 36	425µm	-	-	-	-	-
No. 52	300µm	179	29.0	73.5	26.5	8.30
No.100	150µm	137	22.2	95.7	4.3	0.10
No. 200	75µm					
Total						
Remark						

Fig 2.8 below