ISSN 2229-5518

Evaluation On The Use Of Ordinary Port Land And Portland Pozzolana Cements For Structural Concrete Production

Bekele Arega Demissie[1], Sriharsha Baditala[2], Ashebir Belete[3].

Abstract— This study focuses on evaluating the use of the Dangote Ordinary Portland Pozolana cement for structural concrete production and its production processes of Dangote cement factory with special emphasis to its property as ingredient of structural concrete with regards to quality,eniviroment and minimization of structural cross sections. However, most of the consultants who design structures are simply specifying the ingredients of concrete without enough description of type, reasonable content, and relations with other factors which have direct effect to the hydrolysis reaction of the cements.

This researches discuses results from analysis on the compressive strength test results and rate of gaining strength.by studying how each of the classes of Concrete produced by Ordinary Port land and Portland Pozolana Cement were compared, we found good strength development was observed especially in the high strength concrete, Strength up to54.75% and 58.06% in 3 days and 77.74% and 77.74% and 73.7% in 7 days relative to their28 days strength was possible using the Dangote Portland Pozolana Cements and Ordinary Port land Cement respectively.

Further, we identifies that the OPC is best in high early Strength concrete production. And the PPC cannot produce a 28th day concrete compressive strength as high as that of the OPC.The study also identifies that carbon dioxide emitted more and costs higher than other greenhouse gases during per ton production of Portland cements.

Index Terms — Cement, Greenhouse gases, Compressive Strength, Dangote OPC, Dangote PPC.

1 Introduction

Accordingly, in Ethiopia there are two cement types; namely: Portland Pozzolana Cement (PPC) and Ordinary Portland cement (OPC); and recently, Messebo and Muggier Cement Factory have started to produce a 3rd cement type called Portland Limestone Cement (PLC).

Concrete, the oldest and the most widely used construction material in the construction of civil engineering structures, is a composite material that consists of essentially cements, aggregate and water. Besides, chemical admixtures are essential when special properties are desired. Concrete can be made to possess different properties that comprise strength, elasticity, water tightness, durability and the likes. Concrete strength comprises compressive, tensile and shear strengths; the elasticity stands for modulus of elasticity and creep; and durability of concrete is the ability of concrete to maintain its quality throughout its designed service life.

The primary difference between high-strength concrete and normal-strength concrete relates to the compressive strength that refers to the maximum resistance of a concrete sample to applied pressure. the American Concrete Institute defines high strength concrete as concrete with a cylinder compressive strength greater than 41 MPa (C-50 in Cubic Compressive Strength).

In this thesis, however, such a narrow difference in strength will not be entertained to differentiate normal and high strength concrete. Thus, intermediate strength concrete is going to be introduced between high and normal strength concrete. Thus, by the future context of this paper concrete with compressive strength up to 40 MPa will be considered as normal strength, between 40 and 60 MPa as intermediate and above 60MPa as high strength concrete; and/ orhigh performance concrete.

Producing high-performance concrete is nothing but knowing what factors affect compressive strength and manipulating those factors to achieve the required strength; nowadays, the world is familiarized with the production of Ultra High Performance Concrete (UHPC) up to 200MPa.

1.1 Literature reture review

Several studies have been carried out on the predict OPC and PPC by using different methods. Depending on the oxide composition of the raw materials and homogenizing them,

degree of fineness in grinding the clinker and particle size distribution of the cements even ordinary Portland cement might

- *Bekele Arega Demissie ,, Lecture.,Civil Engg Department ,Assosa University, Ethiopa, PH-0910668976.Email:aregabekalu@gmail.com*
- *Sriharsha Baditala , Assistant Professor & Research Scholar, Civil Engg Department ,Assosa University, Ethiopa, PH-0965619382. Email:sriharsha.geotech2014@gmail.com*
- Ashebir Belete., *lecture.,Civil Engg Department ,Assosa University, Ethiopa, PH-0982848084.Email: itemanchi1888@gmail.com*

vary both in chemical composition and fineness from one manufacturing place to another. Consequently the rate of strength development as well as the ultimate strength may be affected (Abayneh, 1987) [6].

However, the principal compounds, in Portland cement exist not in the form of simple oxides but as minerals of more complex molecular structure.Usual composition limits of Portland cement (Neville A.M., 1996)[5].

The pozzolanic reaction is the chemical reaction that occurs in Portland cement containingpozzolans (Cook D.J, 1986)[3].At the basis of the pozzolanic reaction stands a simple acid-base reaction between calcium hydroxide, also known as Portlandite, or (Ca (OH) 2), and silicic acid (H4SiO4, or Si (OH).At early ages the replacement of cement by a pozzolana usually results in a decrease in the compressive strength, but the difference in strengths becomes less and may disappear at ages of 3months or more (George Earl Troxell and Harmer E. Davis(1956)[1].

A number of tests were carried out by Heath and Brandenburg with Oregon Pumices and their results given illustrating the development of strength of Portland cement mortars with various replacements of pumices are typical of the effect on strength of pozzolanas of medium reactivity. The mortars consisted of 1 part of ordinary Portland cement or 1 part of cement plus pumice to 2.75 parts of Ottawa sand by weight (Orchard D.F, 1973)[2]

Bharat Kumar et al (2001)[10], studied mix proportioning of high performance concrete. The paper concluded that mix proportioning method uses FA as cement replacing material in obtaining economical HPC mix.The adverse effect of an increase in size of the largest particles in the mix exists; in fact, throughout the range of sizes, but below 40 mm (1 ½ in) the advantage of the lowering the water requirement is dominant(Neville A.M., 1996)[5]. Water that is acceptable for drinking (except in respect of bacteriological requirements) is suitable for making concrete. Curing water should be free of materials that significantly affect the hydration reaction of the cement or promote possible alkali – silica reaction or produce unsightly stain or deposition the surface (Tayler W. H., 1997)[7].

2 MATERIALS AND METHODOLOGY

As per Ethiopian Standard of 2005, there are 27 distinct common cement products and their constituents. The definition of each of the cement includes the proportions in which the constituents are to be combined to produce these distinct products in a range of six strength classes. Portland cement clinker is made by sintering a precisely specified mixture of raw materials (raw meal, paste or slurry) containing elements, usually expressed as oxides, CaO, SiO_2, Al_2O_3, $Fe_2O_3$and small quantities of other materials.

2.1 Cement

In this research work, three mixes were prepared using Portland Pozzolana Cement and three mixes were prepared using Ordinary Portland Cement. Both Dangote OPC, produced at different times, and PPC cements were brought from the factory and were fresh. Except the package (the way to identify on the bag), both cements comply with the requirements of Ethiopian Standards, (ES 1177-1,2005).The chemical and physical properties of the cements shown in Table 2.1 & 2.2 are summaries of the cement test result data.

Table 2.1 Physical Characteristics of Cement Grades OPC (BIS Requirements)

		33 Grades	43 Grades	53 Grades
Chemical Characteristics	Lime Saturation Factor	0.8 Min 1.02 Max	0.8 Min 1.02 Max	0.8 Min 1.02 Max
	Alumina ratio, Min.	0.66	0.66	0.66
	Insoluble Residue [%] Max	4	2	2
	MgO [%]Max.	6	6	6
	Max. Sulphuric anhydride	2.5%Maxwhen C3A is 5or less or3%Maxwhen C3A is greater than 5	2.5%Maxwhen C3A is 5or less or3%Maxwhen C3A is greater than 5	2.5%Maxwhen C3A is 5or less or3%Maxwhen C3A is greater than 5
	Losson Ignition [%] max	5	5	4

Table 2.2 Chemical Characteristics of Cement Grades OPC (BIS Requirement)

			33 Grades	43 Grades	53 Grades
Physical Charac-teristics	Fineness[Sq.m/kg], min		225	225	225
	Soundness by	Lechatlir[mm] max	10	10	10
		AutoclaveMax [%]	0.8	0.8	0.8
	Setting Time	Initial[mts] Min	30	30	30
		Final[mts] Max	600	600	600
	Compressive Strength	3day Min [Mpa]	16	23	27
		7day Min [Mpa]	22	33	37
		28day Min [Mpa]	33	43	53

2.2 Fine Aggregates

The fine aggregate used in the concrete productions is natural/river sand. Typical fine aggregate gradation together with its curve is shown in Table 2.3 and Figure 2.1 and its physical properties are shown below in Table 2.3.

Table 2.3 Physical Properties of the Fine Aggregate

No.	Test Description		Test Result
1	Silt Content		1.65%
2	Moisture Content		0.70%
3	Absorption Capacity		3.00%
		Bulk	2.784
4	Specific Gravity	Bulk (SSD)	2.895
		Apparent	2.74
5	Fineness Modulus		2.85

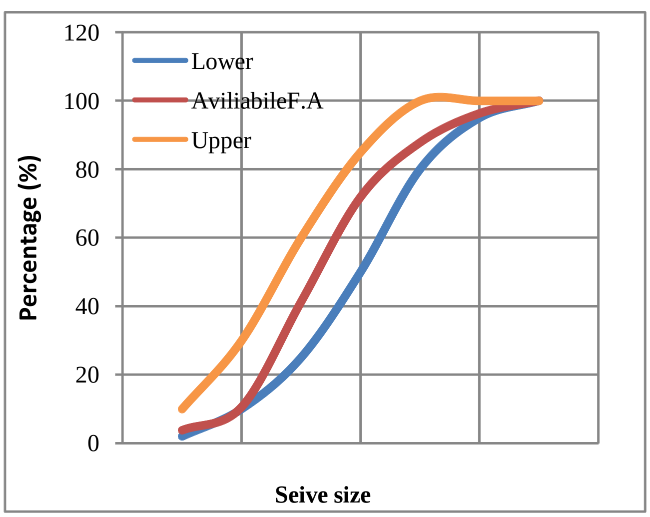

Figure 2.1 Gradation Curve for Fine Aggregate

2.3 Coarse Aggregate

The coarse aggregates used are with maximum aggregate sizes of 20 mm used in the normal strength and intermediate strength concretes production and a maximum aggregate size of 12.5 mm used for high strength concrete production. Typical fine Coarse gradation together with its curve is shown in Table 2.4 and Figure 2.1.

.Table 2.4 Physical Properties of the Coarse Aggregate

No.	Test Description		Test Result
1	Moisture Content		1.16%
2	Absorption Capacity		0.765%
3	Unit Weight		1596kg/m
	Specific Gravity	Bulk	2.74
		Bulk (SSD)	2.76
4		Apparent	2.81
5	Fineness Modulus		1.15%

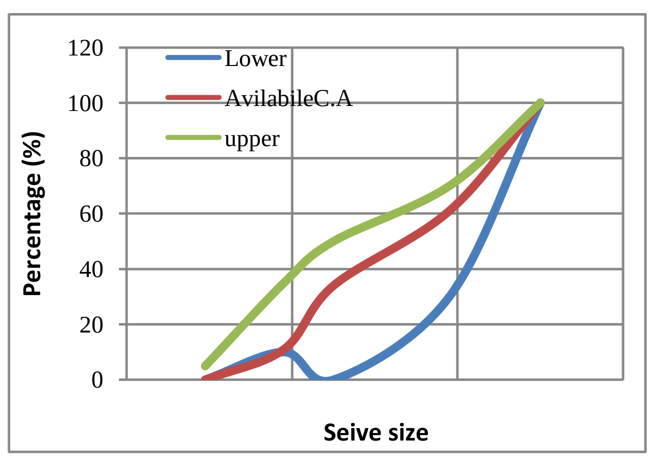

Figure 2.2 Gradation Curve For Coarse Aggregate

ISSN 2229-5518

2.4 Chemical Admixture

Hyper plasticizing admixture based on new generation polycarboxylate ether , Dynamon SP5300, for high performance concrete mixes with very low water cement ratios, high early compressive strengths, long slump retention and self-consolidating & self-compacting concrete is used. It is used to reduce the amount of water and water-cement ratio. Dynamon SP5300 is a chloride free hyper-plasticizing admixture based on the new generation of polycarboxylate ether molecules and is specifically designed for the production of high performance and self-compacting concrete mixes by significantly reducing water/cement ratio and providing excellent results in flow ability and improvement in both fresh and hardened concrete properties; in particular it will enable high early and ultimate compressive strengths to be achieved www.mapei.com.

2.6 Mix preparation

For the purpose of this research two types of cements, namely: Dangote OPC & PPC were used in every concrete class and in the three classes of concrete a total of six mixes were made. In the production of normal strength concrete the targeted strengths was C-25 and in the mix proportions of the intermediate concrete strengths, C-40 were selected andIn the case of the high strength classes of concrete, the targeted strengths was C-70 ACI 211.4R-08 Mix design Method was applied in the three class of concrete.

Table 2.5 Mix Proportions and slumps for concretes made with Dangote OPC

Category	Normal	Intermediate	High
Strengh class	C25	C40	C70
Cement (kg/m³)	290	360	-.
W/C	0.65	0.47	-
Water (kg/m³)	190	170	-
F.A (kg/m³)	607	532	--
C.A (kg/m³)	1290	1367	-
Slump (mm)	80	30	-

Table 2.6 Mix Proportions and slumps for concretes made with Admixture OPC

Category	Normal	Intermediate	High
Strengh class	C25	C40	C70
Cement (kg/m³)	330	400	585
W/C	0.51	0.37	0.24
Water (kg/m³)	170	150	140
F.A (kg/m³)	539	624	604
C.A (kg/m³)	1387	1325	1085
Admixture (lit)	.....	....	8.755
Slump (mm)	20	20	200

3 RESULT AND DISCUSSIONS

The laboratory conducted compressive strength test results on different class of concrete made of the two cements types are analyzed and discussed. Besides correlations are made between concrete properties analyzed using the laboratory test results and proposed using the cement properties test results. During my study of Dangote cement(Ethiopia)PLC, researcher found that name and notation of the cements as to differentiate OPC from the PPC.
The raw data of the compressive test results are summarized and presented in Table 3.1 is further analyzed and summarized in graph as shown on Fig. 3.1 to Fig. 3.4.

To evaluate and compare the rate of strength development among concretes of the same class produced using both cement types, the test results of each concrete at different ages are analyzed relative to their 28th day test result which are tabulated in Table 3.1.

Table 3.1: Compressive Strength Test Results of C-25, C-40 and C-70

Test ages	3 days [MPa]	7 days [MPa]	28days [MPa]	Ratio to its own 28 day compressive		
			Normal Strength			
OPC (C25)	**15.82**	**20.81**	**33.06**	**0.48**	**0.63**	**1**
PPC (C-25)	**15.44**	**25.07**	**30.41**	**0.42**	**0.68**	**1**
			Intermediate Strength			
OPC (C40)	**36.09**	**43.15**	**60.98**	**0.59**	**0.71**	**1**
PPC (C-40)	**28.99**	**39.55**	**55.925**	**0.52**	**0.71**	**1**
			High Strength Concrete			
OPC(C-70)	**49.35**	**62.61**	**82.35**	**0.59**	**0.76**	**1**
PPC (C-70)	**46.54**	**66.08**	**80.49**	**0.59**	**0.82**	**1**

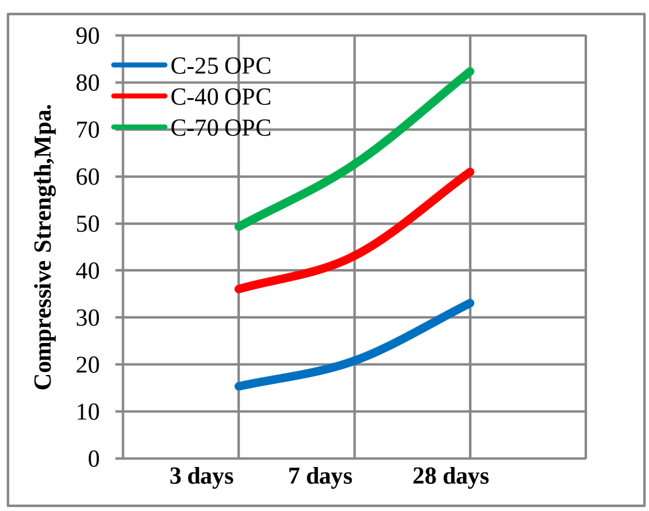

Figure 3.1: Compressive strength development of Dangote OPC

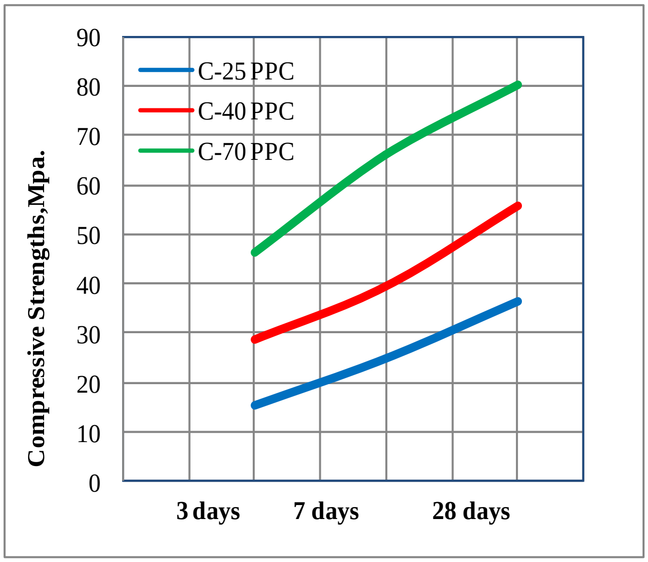

Figure 3.2: Compressive strength development of Dangote PPC.

As shown on figures 3.1and 3.2, for the concretes produced using Dangote OPC and PPC, the increment of three days strengths relative to their respective 28th days strengths are: 46.50%and 44.11% for C-25,60.88% and 52.72%for C-40 and58.06%&54.75% for C-70, by the same token for the seven days, 63.05%&71.63% for C-25,75.85%&71.90 % for C-40and 73.7%&77.74% for C-70. when we see the gap between 3rd days percentage with that of the 7th day of PPC, 27.52% for C-25, 19.18% for C-40 and22.99% for C-70 whereas for OPC 15.61% for C-25, 14.78% for C-40 and 15.64% for C-70; which immediately tells us the rate of increment of PPC is higher than that of OPC in all the three strength classes of concrete; and this was predicted in the literature review due to the late hydration of that ofC_2S.

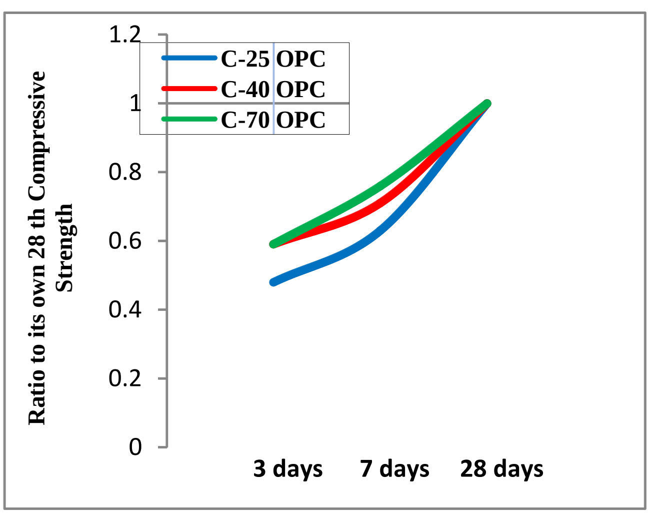

Figure 3.3 : Rate of Strength Development of Dangote OPC Relative to its Own 28th Day's Strength

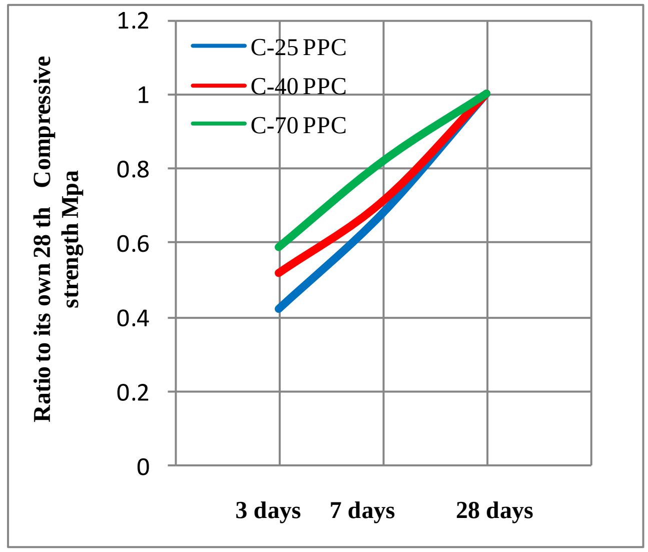

Figure3.4: Rate of Strength Development of Dangote PPC Relative to its Own 28th Day's Strength

As shown in the figure above, keeping every condition the same, OPC gives higher strength than PPC and is highly unlikely that the concrete produced using the PPC can narrow and reach the strength of the concretes made of the OPC up to 28 days. But researches show that the strength development of concrete made of PPC and OPC will have no significant differences at 56 days and more.

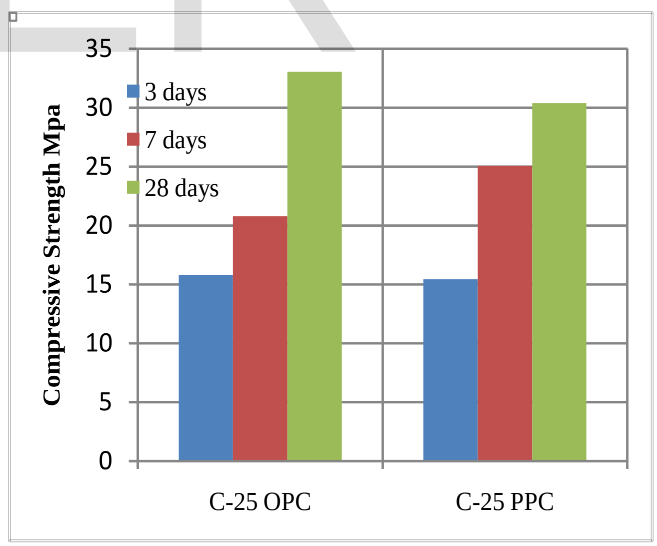

Figure 3.5 Compression of C-25 concrete Strength made with OPC and PPC

In using OPC, at the age of 28 days compressive strengths of: 33.066, 60.98 &82.35MPahave been produced with the possible minimum cement contents respectively for C-25, C-40 and C-70. In the case of PPC, 30.41, 55.925&80.49MPa have been produced respectively for C-25, C-40 and C-70. Therefore, at all ages and classes of concrete, Dangote OPC has produced best compressive strength concrete and is also the PPC as it has pozzolanic material.

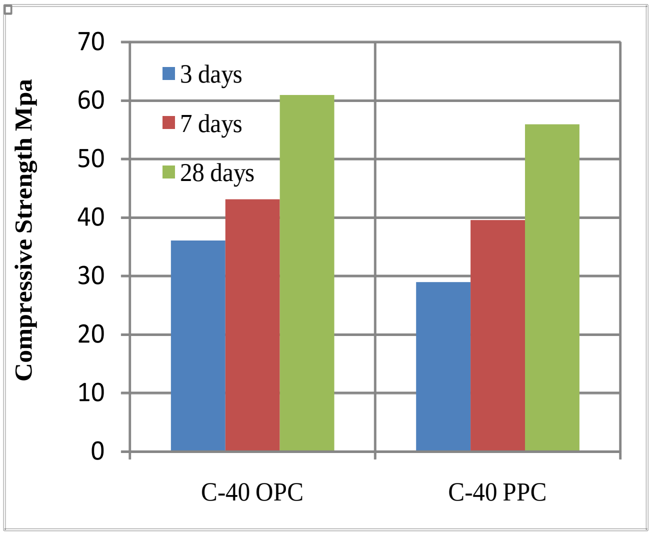

Figure 3.6 Compression of C-40 concrete Strength made with OPC and PPC

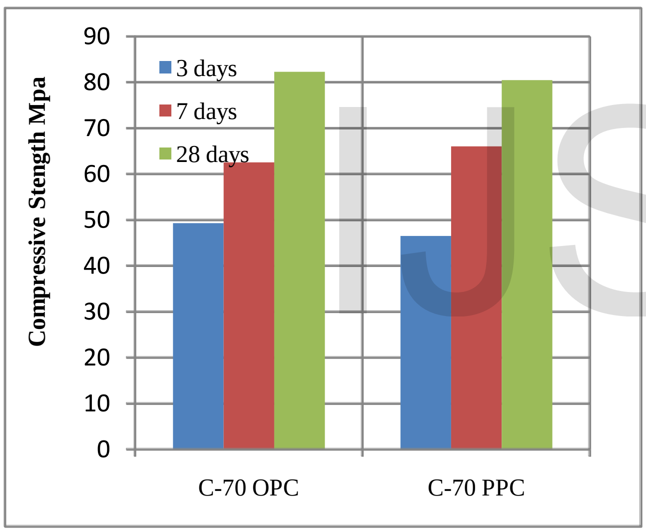

Figure 3.7 Compression of C-70 concrete Strength made with OPC and PPC

4 CONCLUSIONS AND RECOMMENDATIONS

Based on the evaluations made and as reported in the previous results, the following conclusions are drawn and recommendations are forwarded.

[1] The study identifies that carbon dioxide emitted more and costs higher than other greenhouse gases during per ton production of Portland cements.

[2] At all ages andclasses of concrete, Dangote OPC has produced best compressive strength concrete.The PPC cannot produce a 28th day Concrete Compressive Strength as high as that of the OPC.The low Pozzolannicity of the natural Pumice used in the Production of The PPC should be the reason for the ultimate Strength of Concretes made of the PPC to be lower than that of the OPC.

[3] Concrete produced using Dangote PPC has shown the smallercompressive strength and the higher rate of strength increment with age where asthat of OPC hasthe higher strength but the lower rate of strength increment with age; and thus generally, at laterages the PPC has shown larger strength increment as compared to the OPC.

[4] Though the strength differences show a decreasing trend with age, it is highly unlikely that the concrete produced using the PPC can narrow and reach the strength of the concretes made of the OPC.

[5] The pozzolana used in production of the PPC is natural material, Pumice, which has less amount of lime (1.17%), and the ultimate strength achieved from this pozzolana cannot be as high as whatcould be achieved from active pozzolanas such as fly ash. Besides, the hydration of C2S in clinkerand the silicate in the pozzolana requires long moist curing; but in Ethiopia traditional way of construction, curing is given less attention which could not be more than a week. These are, therefore, the threats believed to decrease the ultimate strength of the PPC's concretes.

Acknowledgment

The First and Thired author wish to acknowledge the gratitude goes to **Assosa University** for being the sponsorship of this M. Sc. program, and also to Dangote cement (Ethiopia) PLC as a company for sponsoring the cement needed; and for all who have assisted me in one way or another during the course of preparing and testing of the results.

The Second author wish to acknowledge World Bank funded Technical Education Quality Improvement Program , of Government of Ethiopa, under which the facility used in this study was procured. The support of University Grants Commission of Ethiopa , Assosa University, Assosa, Ethiopa is acknowledged.

References

[1] George Earl Troxell and Harmer E. Davis, (1956) Composition and Properties of Concrete

[2] Orchard, D.F. (1973). Properties of Materials**,** Concrete Technology**,** Volume 1 3rd Edition,

[3] Cook D.J. (1986). Cement Replacement Materials Natural pozzolanas; In: Swamy R.N., Editor Surrey University Press, p. 200.

[4] Portland Cement Association, High Strength Concrete, 2005, www.Cement.org.htmNeville A.M. & Brooks J.J.,

(1987).Concrete Technology, First Published.
[5] Neville A.M. (1996). Properties of concrete, Longman Scientific and Technical Series, 4th Edition.
[6] Abayneh, M. (1987).Construction Materials.
[7] Tayler W. H. (1997). Concrete Technology and Practice, 4th Edition.
[8] Building Research Establishment Ltd, (1997).Design of Normal Concrete Mixes, UK, 2nd edition.
[9] Cement and Concrete Research. (1999). Effects of Cement Particle Size Distribution on Performance Properties of Portland Cement-based Materials, USA, Gaithersburg, MD 20899, Volume 29, pgs.1663-1671.
[10] Bharat Kumar et al, Mix proportioning of high performance concrete, Cement & Concrete Composites 23 (2001) pp.71–80.
[11] Alves M.F.,Cremonini R.A.,Molin D.C.C.Dal, A co parison of mix proportioning methods for high-strength concrete, Cement & Concrete Composites 26 (2004) 613–621.
[12] Canada Concrete Association, (2005).Fast Track Concrete.
[13] ACI &Aqua (2010). ACI Concrete Terminology, &duo; American Concrete Institute, Farmington Hills, MI,http://terminology.concrete.org
[14] ACI Committee E-701, Cementations Materials for Concrete; Materials for Concrete Construction.
[15] ACI 211.4R-08, Guide for selecting proportions for High-Strength Concrete Using Portland cement and Other Cementations Materials.