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HIGH-PERFORMANCE CONCRETE BY USING NATURAL INGREDIENTS TO PREVENT HIGH-TEMPERATURE

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ABSTRACT: This study has been carried out to understand more briefly the effect of high strength concrete High strength concrete is known as result of ongoing research to optimize concrete mixing and to make important contributions to enhanced quality and efficiency in the construction. Changes in temperature can produce stresses in concrete structures. The stresses are produced only when the thermal expansion or contraction is restrained and this will affect the strength of concrete. When concrete is exposed to high temperature, the main problem which will encounter is spalling. This may result of failure in structure and material itself. It is important to consider the actual or realistic behavior in design strength of material uses to protect the structure when exposed to high temperature. The purpose of this study is to compare the performance of high strength concrete with difference percentage of the fly ash and also to investigate the spalling and cracking effect in high strength concrete due to high temperature. The quantities of fly ash that involve were 10% and 15% that replaced the weight of quantities cement in design mixture.

Keywords: High Performance Concrete, fly ash, mix proportions, spalling, compressive strength, and durability

INTRODUCTION

Most of the attention in the 1970s and 1980s was directed toward high strength HPC; today the focus is more on concretes with high durability in severe environments resulting in structures with long life. Concrete is one of the most common material and widely used in construction work. Concrete production is estimated to increase from about 10 billion tons in 1995, to nearly 16 billion tons in 2010 (E.Gjorv and Koji Sakai, 2004). But such increase brings serious implications to the environmental. Today the emerging awareness to reduce the impact it had, through a sustained effort to make concrete. Concrete that has these properties is High Performance Concrete (Sobolev, K.G. and Soboleva, S.V.1998). In the Strategic Highway Research Program (SHRP), HPC was initially defined by three requirements: maximum water-cementitious material ratio of 0.35, minimum durability factor of 80%, as determined by ASTM C 666 method and 21 MPa within 4 hours after placement, 34 MPa within 24 hours and 69 MPa within 28 days. (Caijun Shi dan YL Mo, 2008). As well as time, concrete mixing, process and ingredients has changed. In this new era the increasing complexity of material specification, typified by the wide range of permissible cement types, admixtures and aggregates, reflects the advances in concrete material technology and the commercial pressures of a competitive construction industry. Concrete is one of the most uses in building materials. In the past decades it has explain into a strong and durable construction material. High strength concrete seems to have become the key word in today's concrete technology. In the early 1940s, 30 N/mm2 (at 28 days) was considered to be the representative of high strength concrete. This level jumped to 50 N/mm2 in the late 1950s and early 1960s. Concrete strengths of 100 N/mm2 to 130 N/mm2 is now being viewed as the criteria for high strength. In this study the proportion of the mixture which was developed for f'c 60 MPa, and f'c 80 MPa using local materials that have generally been used ready mix producers. Basic development of High-Performance Concrete on aspects of concrete compressive strength and durability.

PROPERTIES

High-performance concrete characteristics are developed for particular applications and environments; some of the properties that may be required include:

- High durability and long life in severe environments
- Low permeability and diffusion
- Resistance to chemical attack
- High resistance to frost and deicer scaling damage
- Toughness and impact resistance
- Volume stability
- Ease of placement
- Compaction without segregation
- Inhibition of bacterial and mold growth

Property	**Test method**	**Criteria that may be specified**
High strength	ASTM C 39 (AASHTO T 22)	70 to 140 MPa (10,000 to 20,000 psi) at 28 To 91 days
High-early compressive strength	ASTM C 39 (AASHTO T 22)	20 to 28 MPa (3000 to 4000 psi) at 3 to 12 hours or 1 to 3 days
Abrasion resistance	ASTM C 944	0 to 1 mm depth of wear
Low permeability	ASTM C 1202 (AASHTO T 277)	500 to 2000 coulombs
Chloride penetration	AASHTO T 259 & T 260	Less than 0.07% Cl at 6 months
High resistivity	ASTM G 59	
Low absorption	ASTM C 642	2% to 5%
Low diffusion coefficient	Wood, Wilson and Leek (1989) Test under development by ASTM	1000 x 10–13 m/s
Property	**Test method**	**Criteria that may be specified**
Resistance to chemical attack	Expose concrete to saturated in wet/dry environment	No deterioration after 1 year
Sulfate attack	Sulfate attack ASTM C 1012	0.10% max. expansion at 6 months for moderate sulfate exposures or 0.5% max. expansion at 6 months for severe sulfate exposure
High modulus of elasticity	ASTM C 469	More than 40 GPa (5.8 million psi) (Aitcin 1998)
High resistance to freezing and thawing damage	ASTM C 666, Procedure A	Durability factor of 95 to 100 at 300 to 1000 cycles (max. mass loss or expansion can also be specified)
High resistance to deicer scaling	ASTM C 672	Scale rating of 0 to 1 or mass loss of 0 to 0.5 kg/m3 after 50 to 300 cycles
Low shrinkage	ASTM C 157	Less than 400 millionths (Aitcin 1998)
Low creep	ASTM C 512	Less than normal concrete

Table **1.1** *Selected Properties of High-Performance Concrete*

High-performance concretes are made with carefully selected high-quality ingredients and optimized mixture designs; these are batched, mixed, placed, compacted and cured to the highest industry standards. Typically, such concretes will have a low water-cementing materials ratio of 0.20 to 0.45. Plasticizers are usually used to make these concretes fluid and workable.

MATERIALS AND METHODOLOGY

High-performance concrete almost always has a higher strength than normal concrete. However, strength is not always the primary required property. For example, a normal strength concrete with very high durability and very low permeability is considered to have high-performance properties. Bickley and Fung (2001) demonstrated that 40 MPa (6,000 psi) high-performance concrete for bridges could be economically mad while meeting durability factors for air-void system and resistance to chloride penetration.

Table.**1.1** of Material used in high performance concrete

Mixture number	**1**	**2**	**3**	**4**	**5**	**6**
Water, kg/m3	150	144	135	145	132	132
Cement, kg/m30	311	396	500	333	512	312
Fly ash, kg/m3	31	45	---	---	---	40
Slag, kg/m3	44	---	122	---	---	---
Silica fume, kg/m3	16	32	30	40	43	22
Coarse aggregate, kg/m3	1069	1030	1100	1130	1080	1140

Table **1.2** Chemical compositions and physical properties of Portland cement Type I

Vicat Test		Compressive Test (ASTM)	
Initial	≥ 43min	3 day	≥ 1640 psi
Final	≤ 65min	7 day	≥ 2720 psi

Table 1.3 Mix proportions

Mixture Proportions Kg/m3	f'c 40 MPa	f'c 60 MPa	f'c 80 MPa
Cement	412	500	600
Fly ash	73	-	
Silica fume	-	75	120
Ratio water /binder	0.39	0.20	0.23
Water	189	115	165,5
Sand	634	641	603
Gravel	1038	1092	1119
Superplasticizer			
Pozzolith 100 Ri ex BASF	1,44		-
Viscocrete 10 ex Sika	-	3,45	15

RESULTS AND DISCUSSION

The result from laboratory works for concrete compressive strength (C60) at 28 days shows that the different compressive strength between 10% and 15% concrete that has been added with cementitious material fly ash.

Material in Concrete Containing 10% Fly Ash

After deciding mix design for concrete grade 60 that containing 10% fly ash, the weight of cement, sand, water, coarse aggregate, fine aggregate and fly ash is determined. The weight of this material is shown in table 3.1

Table 1.4: *Quantity material used in casting concrete containing 10% fly ash*

LAB RESULTS FOR 12% fly Ash		
Cement	=	6.714 Kg
Water	=	2.4 Kg
Fine aggregate	=	10.05 Kg
Coarse aggregate	=	17.43 Kg
Fly ash	=	0.686 Kg

Slump Test (Between 10 mm - 30 mm)
10 mm

Material in Concrete Containing 15% Fly Ash

From the mix design also, the same step was repeated for the concrete containing 15% fly ash to determine the quantity material used for these mixing processes. The value that been calculated is shown in table 3.2.

Table **1.5** Quantity material used in casting concrete containing 15% fly ash

LAB RESULTS FOR 16% fly Ash		
Cement	=	5.83 Kg
Water	=	2.4 Kg
Fine aggregate	=	10.05 Kg
Coarse aggregate	=	17.43 Kg
Fly ash	=	1.029 Kg

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Slump Test (Between 10 mm - 30 mm)
9 mm

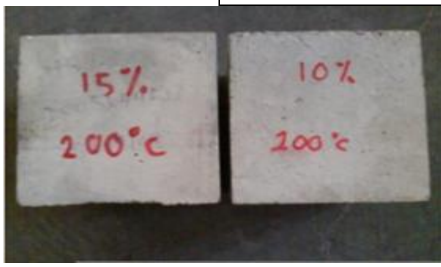

Figure 1.1: The concrete containing 10% and 15% fly ash after exposed to 200°

Figure 1.2: The concrete containing 10% and 15% fly ash after exposed to 400°C

Figure 1.3: The concrete containing 10% and 15% fly ash after exposed to 600°C

Figure1.4: The concrete containing 15% 10% fly ash after exposed to 800°C

Table **1.6**: Result obtained from Compression Test for concrete containing 10% fly Ash

Temperature (°C)	Maximum load (kN)	Compressive strength (kN/m2)
room	583	58.3
200	475	47.5
400	456.4	45.64
600	445.6	44.56
800	296.7	29.67

Table 1.7: Result obtained from Compression Test for concrete containing 15% fly ash

Temperature (°C)	Maximum load (kN)	Compressive strength (kN/m2)
room	622	63.2
200	613	63.3
400	566	56.6
600	464.6	47.46
800	338.2	33.82

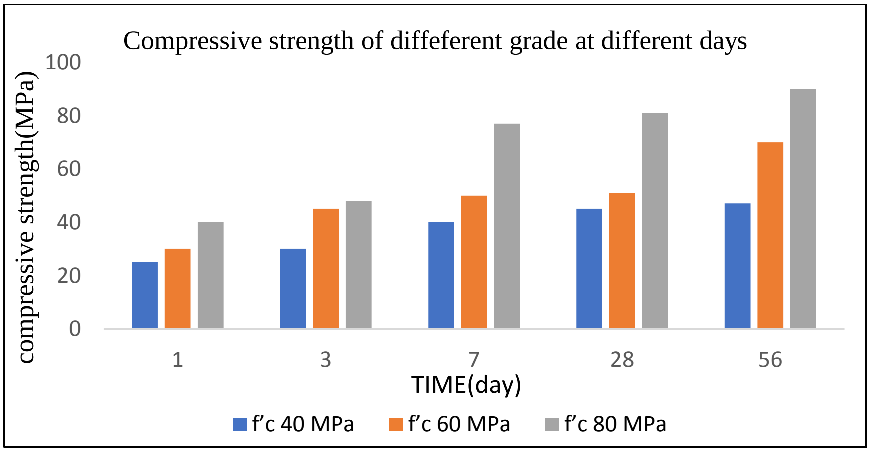

Fig. 1.5 Result of Compressive Strength at different days

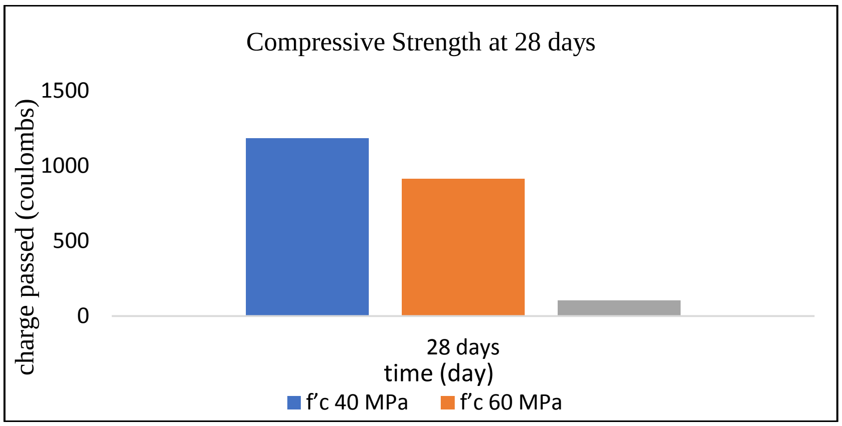

Fig. 1.6 Result of Compressive Strength at 28days

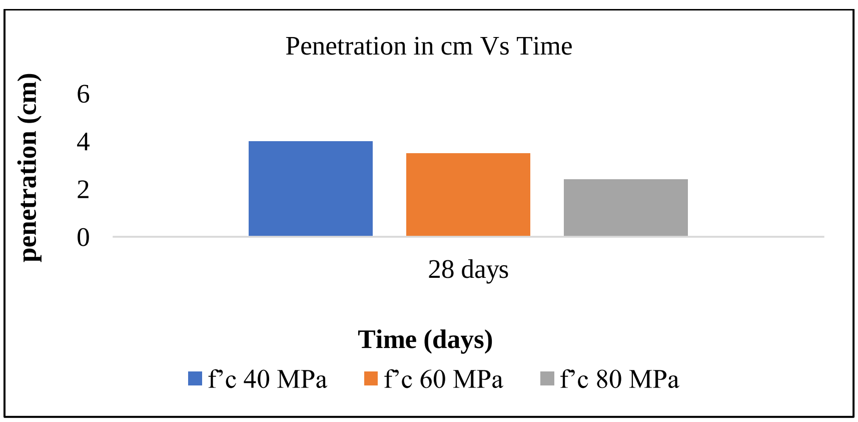

Fig. 1.7 Result of Permeability

The maximum course aggregate size mainly influences the cement paste requirement in the concrete. The aggregate shape and texture can influence the workability, bonding, and compressive strength. At the same water/binder and with the same cement content, aggregate with angular shape and angular and rough surface texture result in lower workability but lead to better bond and better mechanical properties. Sand/coarse aggregate ratio will influence the packing of concrete. Increase of the sand to coarse aggregate ratio can lead to an increase of cohesiveness, but reduces the consistency. Of all the measure for improving the cohesiveness of concrete, increasing sand/coarse aggregate ratio has been proven to be the most effective one. The aggregate /cement ratio has an effect on the concrete cost, workability, mechanical properties, and volume stability. Increasing the aggregate/cement ratio will decrease the cost of concrete, and improve concrete's dimension stability due to reduction of shrinkage and creep. The concrete properties, both in fresh and hardened states, can be modified or improved by admixture, concrete strength can be improved by silica fume.

CONCLUSION

- More high temperature gave more cracks for concrete
- The concrete containing 15% fly ash after elevated at different temperature is more than cracks compared to concrete containing 10% fly ash
- The workability of concrete with fly ash are all passes the requirements of workability
- The slump drop at the range 10 mm - 30 mm. From the results it can see that concrete with 15% fly ash have compressive strength is higher than concrete with 10% fly ash.

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