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Effect of the Curing Conditions and Superplasticizer on Compressive Strength of Concrete Exposed To High Ambient Temperature of Nawabshah, Pakistan

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Abstract: ***The overall performance of the hardened concrete is believed to be greatly affected by the type and duration of the curing. The influence of the curing on the strength and durability of concrete becomes more significant when the concrete is to be exposed to high ambient temperature of the local area. This paper presents the results of an experimental study conducted to investigate effect of curing conditions and superplasticizer on compressive strength of concrete exposed to high ambient temperature. The cube specimens of standard size were cast and tested. The superplasticizer was used as percentage of cement being 0% to 2% with an increment of 5%. The specimens were cured initially in water for 3days, 7 days and 14 days and then exposed to the ambient environment up to the testing age. All the specimens were tested at 28 days. In addition, a batch of the specimens was cast and cured continuously in water for 28 days and another batch of the specimens was exposed to the high ambient temperature without initial wet curing. Both the batches were also tested at 28 days age. The results were compared to investigate the effect of initial wet curing and superplasticizer on compressive strength when it is exposed to the high ambient temperature. The results reveals that the compressive strength of concrete exposed to the high ambient temperature is significantly influenced by the wet curing period and the addition of superplasticizer.***

Keywords: Concrete, compressive strength, curing, superplasticizer, ambient temperature.

Introduction

The manufacture of a concrete possessing desirable strength and durability without proper and adequate curing if not impossible but at least is next to impossible. The type and duration of the curing has been proved to be one essential feature to produce the concrete and mortar of required performance in both the terms; strength and durability, for which it has been produced despite the concrete is without or with the admixtures and cementitious materials [i –x]. A large number methods is in practice for curing of the concrete including ponding, covering the exposed surfaces of concrete with wet burlap, addition of curing compounds, application of protective membranes over the surface of the concrete etc [xi - xiii]. Among these methods, the wet/ moist curing is believed to be most effective and appropriate method. Following the placement, compaction and the finishing of the concrete/ mortar in the formwork, the drying of the concrete during its hardening is preserved by ensuring the existence of water/moisture and the humidity up to specific period [xiv]. Though, the strength gain of concrete remain continue for a very long time if moisture and humidity required for the purpose exist there [xv]. However, normally, it is believed that the concrete may be cured in water up to 28 days to gain sufficient strength. The ACI Code specifies 7 days wet curing as minimum duration to cure structural concrete [xvi].

Literature reports the effect of the moist and dry curing by mentioning a difference of the compressive strength of 58% [xvii] which may be offset by prolonged initial curing [ii]. However, another research has reported that the air cured specimens showed 17-22% less compressive strength at 28 days when it was compared to the moist cured specimens of the same proportion [xviii]. The performance of hardened concrete is greatly affected by the ambient temperatures also. Higher the ambient temperature, more is the water demand by the concrete due to increased temperature of the concrete in fresh state causing the faster hydration thereby affecting its long-term strength if not adequately cured [ii, xvii]. The concrete in hot climates also may cause plastic shrinkage thus affecting its mechanical properties and durability when hardened [xv].

The superplasticizer is one of the admixtures added to concrete either to reduce water-cement ratio or to increase the workability of the concrete particularly it's casting in hot weather. Since, the superplasticizer is believed to behave as retarder also to the limited extent which might offset the increased water demand of the concrete when it is manufactured in high temperatures thus reducing the adverse effect on the performance of the concrete.

Nawabshah is located in the centre of Sindh province of Pakistan where almost during eight months of the year there is hot season. The ambient temperature remains between 40℃ and 50℃ during the four months i.e., May to August. This results in adverse effects on the performance of the concrete if the proper attention is not paid in terms of the type and the duration of curing of the concrete cast during these months. This study focused to investigate experimentally the effect of the initial wet curing duration and superplasticizer on the

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compressive strength of the concrete under high ambient temperature of Nawabshah, Pakistan.

I. Materials and Methodology

During the present study, concrete of proportion 1:2:4 was prepared with Ordinary Portland Cement of Type-I. Crushed aggregate of maximum size 20mm and fine hill sand passing from #16 sieve was used as coarse and fine aggregate respectively to manufacture the concrete with fixed water/cement ratio of 0.5. Superplasticizer of SNF group in liquid form was added in the concrete from 0% to 2% with an increment of 0.5% by weight of cement. Before the casting of the specimens slump value of the concrete without and with superplasticizer was determined. The cube specimens of standard size were cast and after one day the specimens were demoulded and exposed to the specific curing condition. The details of the curing conditions are given in table 1. Entire the specimens were tested at 28 days to determine the compressive strength of the concrete. The specimens were tested at gradual and constant rate of loading in UTM (universal testing machine) installed in the structures laboratory of Civil Engineering, QUEST, Nawabshah, Sindh Pakistan.

Table 1: Details of the curing conditions

S.No.	Curing designation	Description of curing
01	C-1	Immersed in the water
02	C-2	14 days immersed in water then exposed to ambient temperature (44℃ – 49℃)
03	C-3	07 days immersed in water then exposed to ambient temperature (44℃ – 49℃)
04	C-4	03 days immersed in water then exposed to ambient temperature (44℃ – 49℃)
05	C-5	Exposed to ambient temperature (44℃ – 49℃) immediately after demoulding the specimens without initial water curing

II. Results and Discussions

Table 2 presents the slump values of the concrete with and without superplasticizer. It is obvious from the table values that as expected, the slump of the concrete increases with the addition of the superplasticizer. However this increase is more pronounce up to the 1% superplasticizer. The increase of the slump diminishes/retrogrades with further addition of superplasticizer beyond 1% i.e 1.5% & 2% by weight of cement. This infers that 1% of the superplasticizer may be considered as optimum dosage in order to increase the workability of the concrete.

Table 2: Slump values of concrete

S.No.	Superplasticizer (%)	Slump (mm)
01	0.0	03
02	0.5	10
03	1.0	17
04	1.5	22
05	2.0	25

The values of average compressive strength determined are tabulated in Table 3and depicted graphically in Figure1. The compressive strength of the concrete is highest when it is cured under C-1 curing condition (immersed in water up to the testing). The lowest average compressive strength is obtained in the case when it is exposed to the higher ambient temperature of Nawabshah varying between 40℃ and 50 ^{0}C. However, the initial wet curing and its duration before the exposure of the specimens to higher ambient temperature exhibited significant effect on the increase of the compressive strength. The specimens subjected to 14 days initial wet curing yielded compressive strength from 80% to 90% of that of the wet cured specimens. This infers the importance of the wet/ moist curing of the concrete to achieve its desired strength. The values of the Table 3 show that the average compressive strength of the concrete is significantly increased with the addition of the superplasticizer also in all the curing conditions including the concrete exposed to higher ambient temperature without wet curing. The maximum compressive strength in all the cases of the curing condition is obtained with 1% superplasticizer which may be considered as optimum dosage even in case of the concrete to be exposed to higher ambient temperature. The graphical comparison is presented in Figure 2. This fact may be clearly observed from the values presented in Table 4 and Figure 3 also, where the effect of the superplasticizer on compressive strength gained by the concrete in different curing conditions is calculated in terms of percentage of the strength of concrete with same superplasticizer dosage and cured in C-1 condition.

Table3: Average compressive strength of concrete

S.No.	Curing condition	Average compressive strength (MPa)				
		0% Sp	0.5% SP	1.0% SP	1.5% SP	2.0% SP
01	C-1	33.9	37.2	41.2	36.9	31.9
02	C-2	28.7	34.2	39.1	33.7	28.8
03	C-3	24.1	28.9	31.6	28.2	24.1
04	C-4	20.2	24.3	25.7	23.3	21.7
05	C-5	16.3	21.1	23.9	22.1	19.3

It is worth noting that that addition of the superplasticizer in the concrete facilitates the strength gain of the concrete even in worst condition of the curing i,e is C-5 when concrete was exposed to higher ambient temperature immediately after demoulding without initial wet curing.

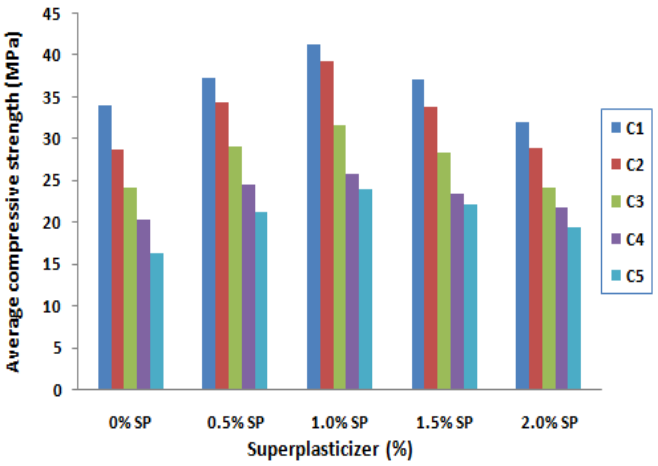

Figure 1: Effect of curing conditions on average compressive strength of concrete

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In this case, the concrete without superplasticizer gave 48% strength under C-5 whereas the same concrete with 2% superplasticizer under the same curing condition gave 60% average compressive strength to that of the respective concrete cured in C-1. This infers the positive effect of the superplasticizer in terms of strength gain if the concrete is to be exposed to higher ambient temperature.

Table 4: Effect of SP on strength exposed to different curing conditions

S.No.	Curing condition	Average compressive strength as %age of respective strength of concrete cured in C-1 condition				
		0% Sp	0.5% SP	1.0% SP	1.5% SP	2.0% SP
01	C-1	100	100	100	100	100
02	C-2	85	92	95	91	90
03	C-3	71	78	77	76	76
04	C-4	60	65	63	63	68
05	C-5	48	57	58	60	60

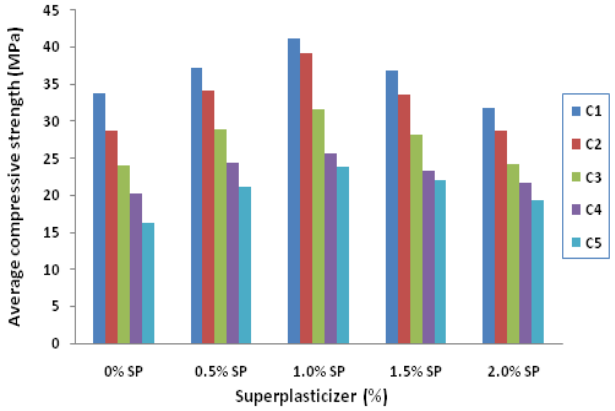

Figure 2: Effect of superplasticizer on average compressive strength of concrete under different curing conditions.

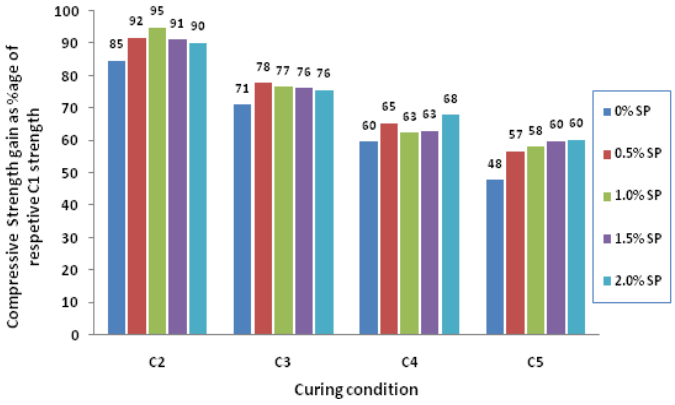

Figure 3: Compressive Strength gain as %age of respective concrete cured in C-1 due to different SP dosage.

III. Conclusions:

Based on the results and discussions made, it may be concluded that the compressive strength of the concrete is significantly affected when it is exposed to higher ambient temperature. However the initial wet curing of about 14 days offsets this aspect subsequently. Also the addition of superplasticizer facilitates the concrete to achieve considerable strength in the higher ambient temperature even if it is not subjected to initial wet curing before exposing to higher ambient temperature like at Nawabshah, Sindh Pakistan, where the ambient temperature reaches to 50 ^{0}C in summer.

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