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Influence of different chemical admixtures in achieving high early strength concrete

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Abstract. High early strength concrete is fundamentally developed to provide a better solution to early housing and rehabilitation projects. Investigation in this project focuses primarily upon various industrial based accelerating admixtures which are dispensed in concrete mix in various dosages to obtain a high efficient mix. The specimens were casted and subjected to chemical and moisture curing. Fresh concrete properties like slump for workability and penetration resistance to analyse very early strength were done. Compressive strength at 1, 3, 7, 28 days were observed in order to identify the optimum dosage of accelerating admixtures. The result obtained showed that the type Y accelerator and chemical curing are the most suited to achieve high early strength concrete.

1. Introduction

Concrete is the most widely used product all over the world as most of the construction is dependent upon concrete in its variable forms. High early strength concrete is one of the major concrete used in construction industry now days as it imparts high early strength which is needed in high pace and efficient construction. The major point of difference in this type of concrete is due to its efficiency in initial period. The strength gain involves faster interaction of water and cement particles which ultimately turns out to be accelerated hydration of cement. Basically in hydration, high early strength comprise of more Ca and SO_4 quantity which accelerates the production of calcium hydroxide (CH), calcium silicate gel (CSH) and calcium aluminate hydrates (CAH) imparts strength in minimum amount of time (Ramachandran, 2002). The resulting concrete should gain strength in very early amount of time and durability aspect should also be given utmost weight-age while designing the concrete as majority of repairs and precast elements fail due to lack of durability. The major acceleration property to high early strength concrete is mainly imparted by accelerators (Mehta and Monteiro, 1998). The accelerators are categorized by the presence and absence chloride ion. Chloride ion accelerators are cheap and easily available but unable to prove its efficiency in long term durability aspects and act as poisons to reinforcement. Non chloride accelerators could be of various organic or inorganic components like nitrates of calcium and sodium or amines, carboxylic acid. Now, the accelerators are also revolutionized and the chemical companies are producing hybrid accelerators which are blended mixtures of various components and chemicals resulting into an effective strengthened, workable and durable mix.

Min et al. (2014) reported the development of compressive strength of early concrete age using calcium based hardening accelerator and high early strength cement. Novinson and Crahan (1988) used Lithium salt as set accelerator for refractory concretes and correlated the chemical properties with setting time. Aggoun et al. (2008) demonstrated the effect of admixtures on the setting time and strength evolution of cement pastes at early ages. Cassagnabre and Escadeillas (2009) studied that Curing method and temperature also plays a major role in obtaining the early strength of concrete. Adoption of curing methods depends upon the characteristics of the project. Majorly in precast industries water bath and steam curing is adopted to get initial high result. Chemical curing is also an effective manner to induce very high early strength. In this experimental study, three types of accelerating admixtures at various dosages and two types of curing namely moist curing and chemical curing is used to identify the influence of both the admixture dosage and curing which results in high early strength.

2. Materials and Methods

2.1 Materials

Cement of 53 Grade, locally available coarse aggregate and river sand has been used in the concrete mix reported. Three types of commercially available accelerators have been used as shown in Table 1. The accelerator type X is sodium based while the type Y is calcium based.

Table 1. Details of the materials used

MATERIAL	SOURCE
Cement	PENNA OPC 53
20 mm coarse aggregates	Locally available
12.5 mm coarse aggregates	Locally available
River sand	Locally available
Varaplast 123 (Control sample superplasticizer)	Aakarsh Chemical
Sika Viscocrete HDP20 (Accelerator X)	SIKA Chemicals
Plastol Ultra 209 (Accelerator Y)	EUCLID Chemicals
Masterset AC 100 (Accelerator Z)	BASF Chemicals
Perma Cure WB white (curing agent)	PERMA const. Aids Pvt. Ltd

2.2 Methodology

Concrete samples of M_{50} grade were prepared with different dosage of admixtures. Table 2 represents the dosage mixed and number of specimens casted for each sample. The specimens were tested for two curing condition i.e. moisture curing by keeping the specimens in the mist room and chemical curing by applying curing agent at each face of the specimens. Fresh properties were tested through the slump test (IS 7320:1974); Penetration resistance test for strength gain (IS 8142:1976). Hardened strength was tested for 1, 3, 7, 28 days and the effect of accelerator has been observed by comparing both the samples on the basis of fresh concrete properties and compressive strength. The average strength of three specimens was taken to report the compressive strength. Table 3 shows the quantities of materials involved in the mix proportioning.

Table 2. Details about the dosage of accelerator used

Sample	Accelerator	Dosage % (by weight of cement)	Number of samples for 1,3,7 & 28 days , both curing condition
A	CONTROL SAMPLE	NONE	24
B1	X	0.5	24
B2	X	0.7	24
B3	X	0.9	24
B4	X	1.1	24
C1	Y	0.5	24
C2	Y	0.65	24
C3	Y	0.8	24
C4	Y	0.95	24
D1	Z	0.5	24
D2	Z	0.7	24
D3	Z	0.9	24
D4	Z	1.1	24

3. Experimental Results

3.1 Slump test

Slump Test is related with the ease with which concrete flows during placement and most widely used test to check the consistency (IS 7320:1974). Table 3 depicts the slump values of at different retention time for all the samples.

Table 3. Slump values obtained (mm)

Samples	Type of accelerator	Accelerator dosage	Retention time (min)				
			0 (Initial)	30	60	90	120
A	-	-	150	135	125	100	90
B1	X	0.5	100	75	60	50	25
B2	X	0.7	150	140	130	110	100
B3	X	0.9	190	180	170	140	125
B4	X	1.1	No slump		200	190	180
C1	Y	0.5	110	100	90	80	65
C2	Y	0.65	160	150	140	125	110
C3	Y	0.8	200	170	160	150	145
C4	Y	0.95	No slump		240	200	180
D1	Z	0.5	140	130	125	120	110
D2	Z	0.7	140	130	125	120	110
D3	Z	0.9	140	130	125	120	110
D4	Z	1.1	140	130	125	120	110

3.2 Penetration resistance test

This is carried out to check initial strength at very initial level pertaining to IS: 8142:1975. figures 1 to 4 depicts the variation of penetration resistance offered by various mixes.

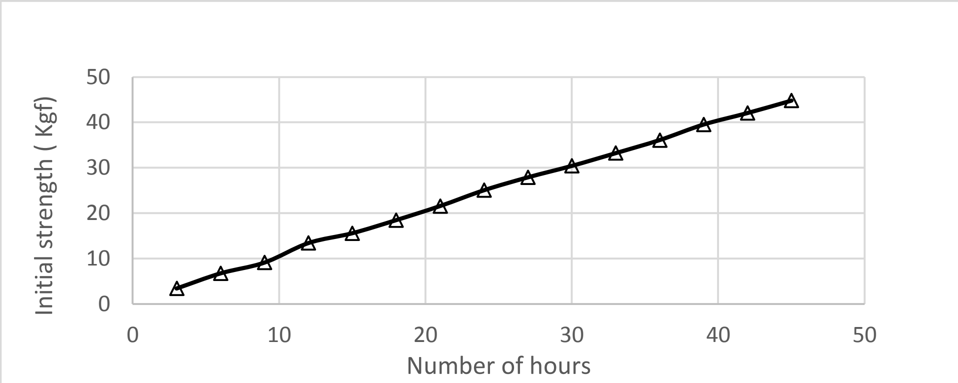

Figure 1. Variation of penetration resistance of the mix A without accelerator

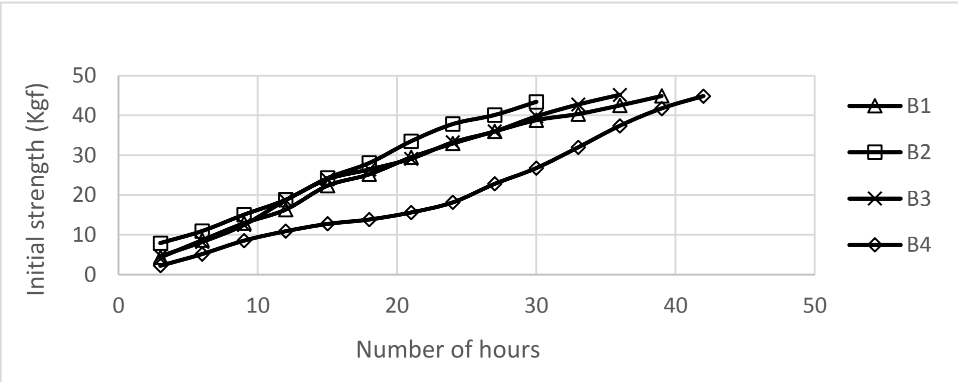

Figure 2. Variation of penetration resistance of the mix B

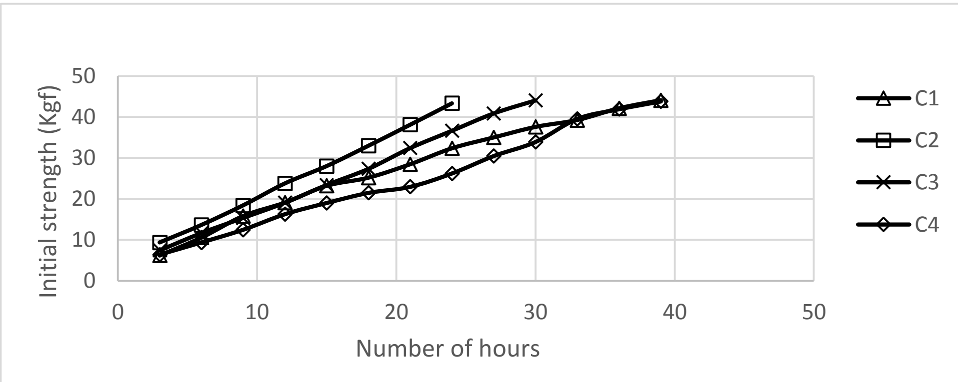

Figure 3. Variation of penetration resistance of the mix C

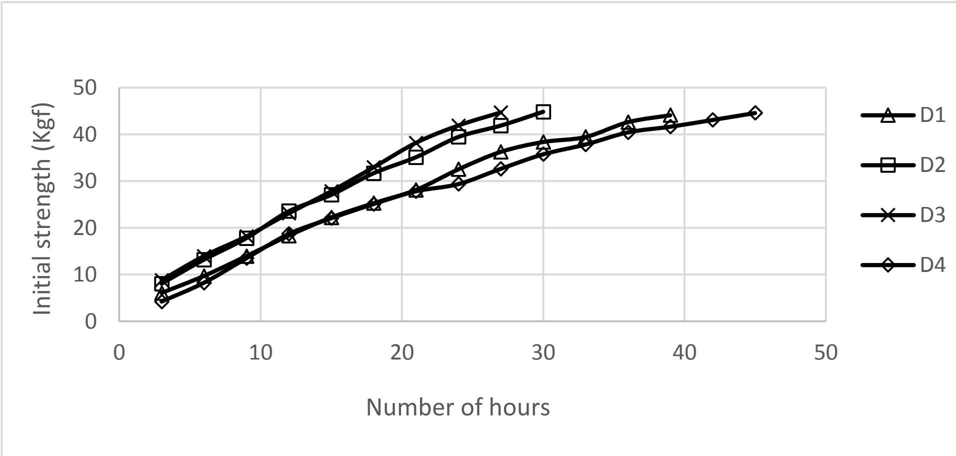

Figure 4. - Variation of penetration resistance of the mix D

3.3. Compressive strength test

The compressive strength of various concrete mixes was tested and results obtained for 1,3,7 and 28 days are shown in figures 5 to 12.

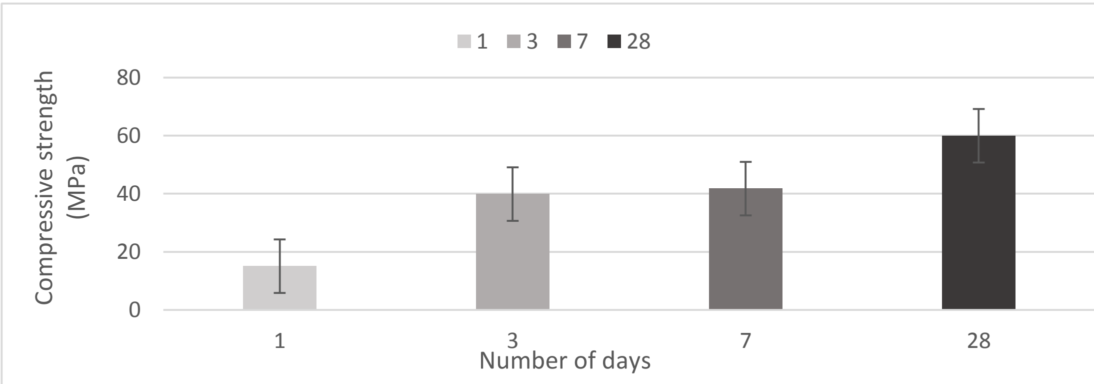

Figure 5. Influence of moist curing for control sample A without accelerator

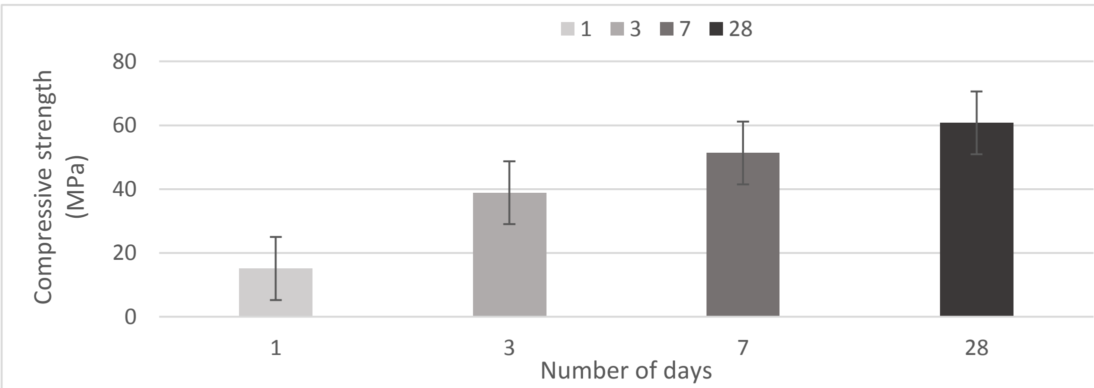

Figure 6. Influence of chemical curing for control sample A without accelerator

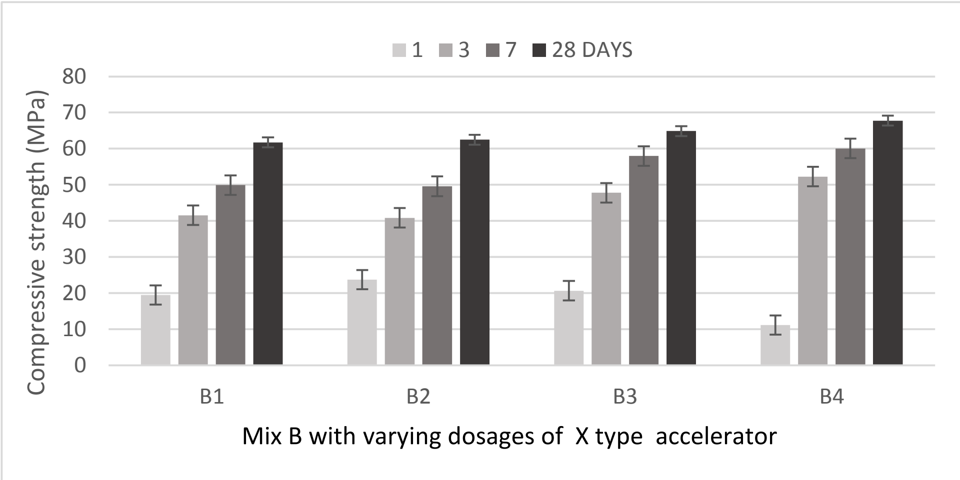

Figure 7. Influence of moist curing in the mix B

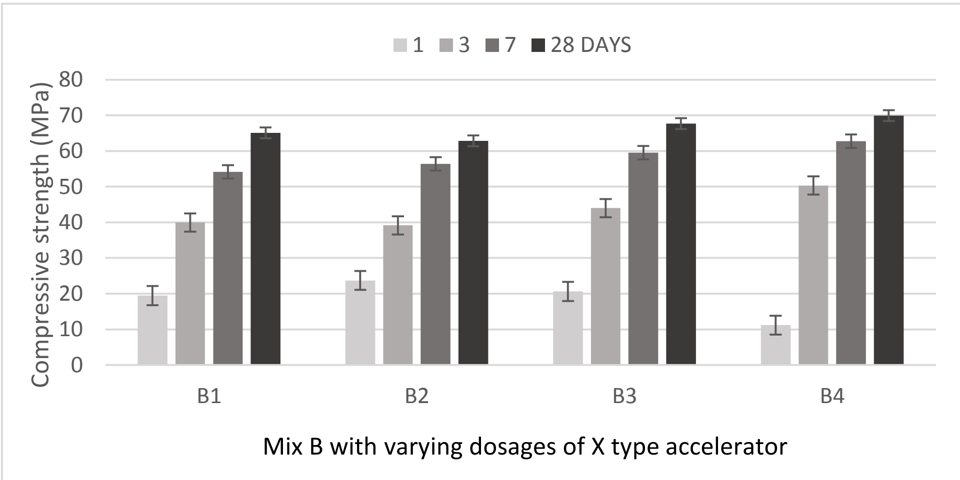

Figure 8. Influence of chemical curing of mix B

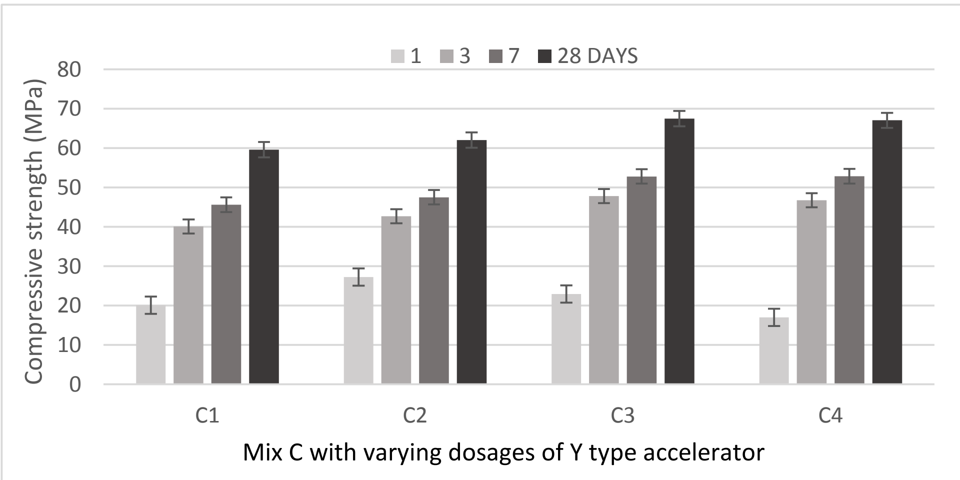

Figure 9. Influence of moist curing of mix C

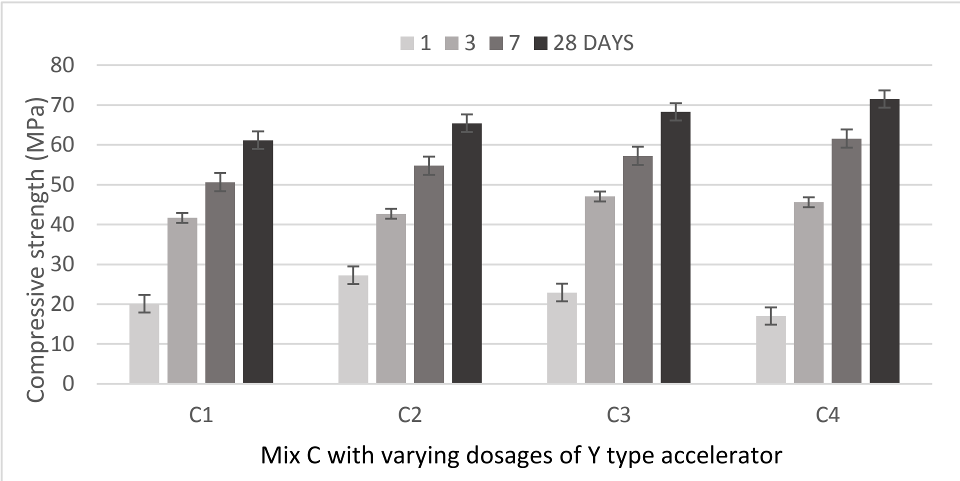

Figure 10. Influence of chemical curing of mix C

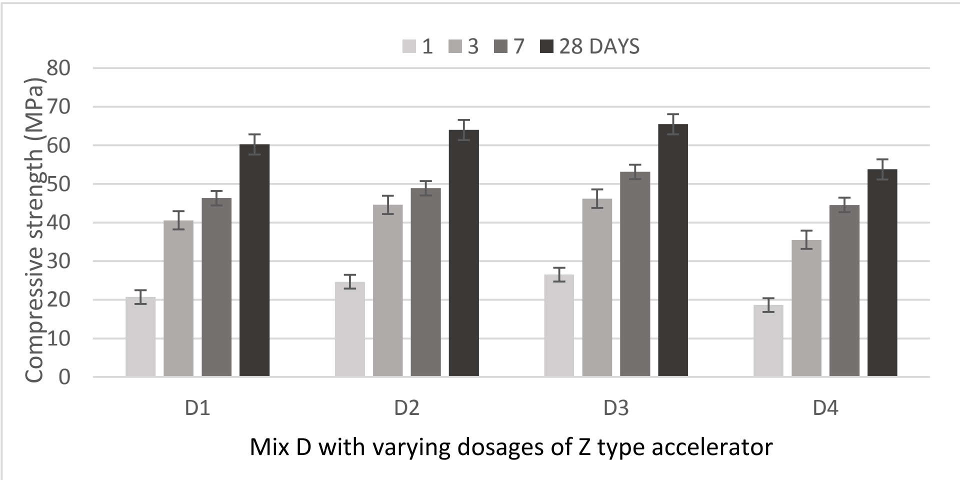

Figure 11. Influence of moist curing of mix D

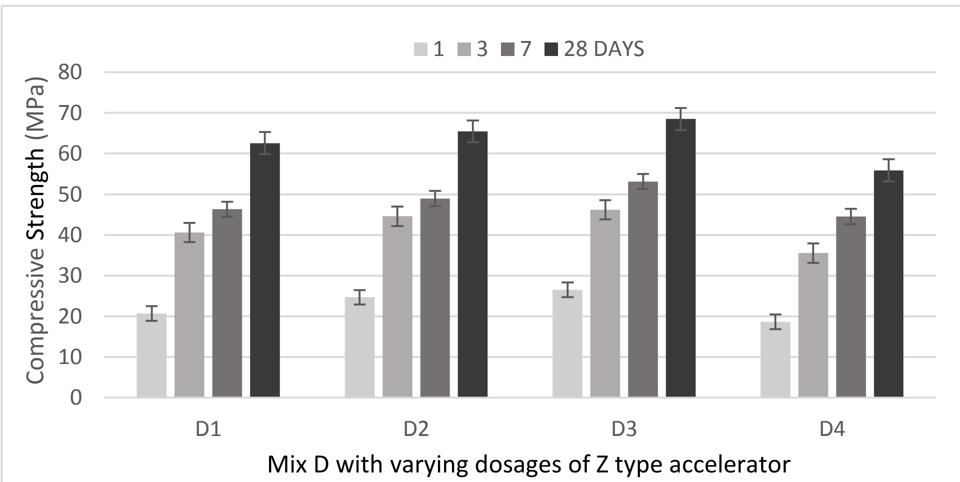

Figure 12. Influence of chemical curing of mix D

3.4 Comparative study of moist curing and chemical curing of samples

This comparative study, figures 13 and 14 illustrates the comparison of strength of various accelerators under both the curing conditions for specified days.

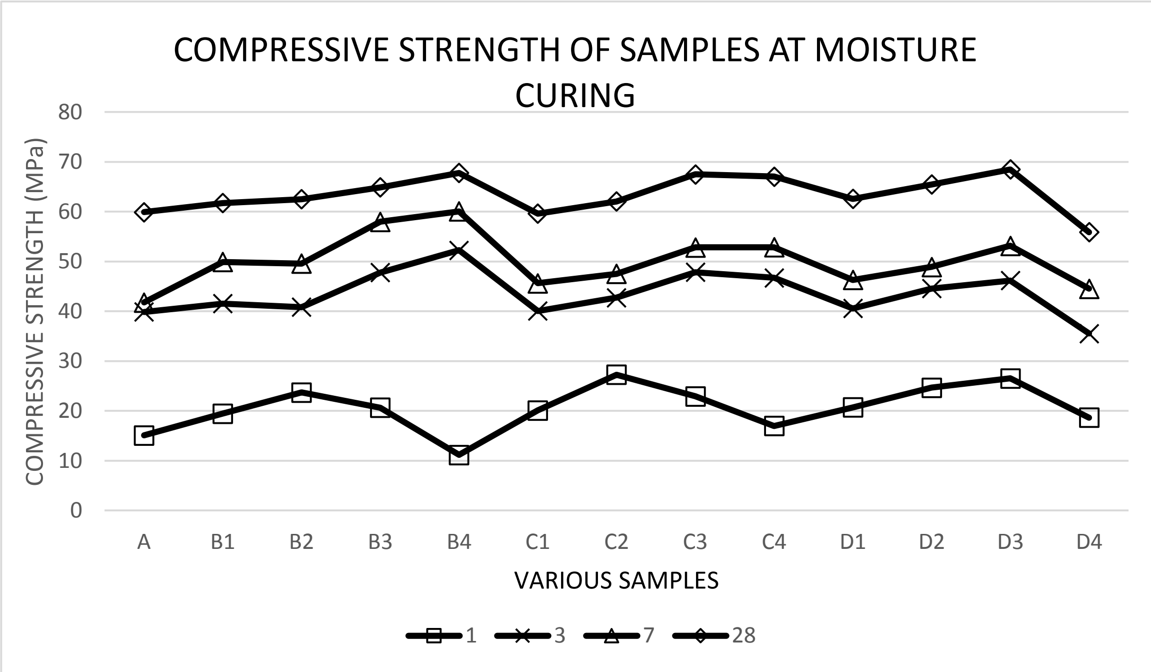

Figure 13. Influence of moist curing of various samples

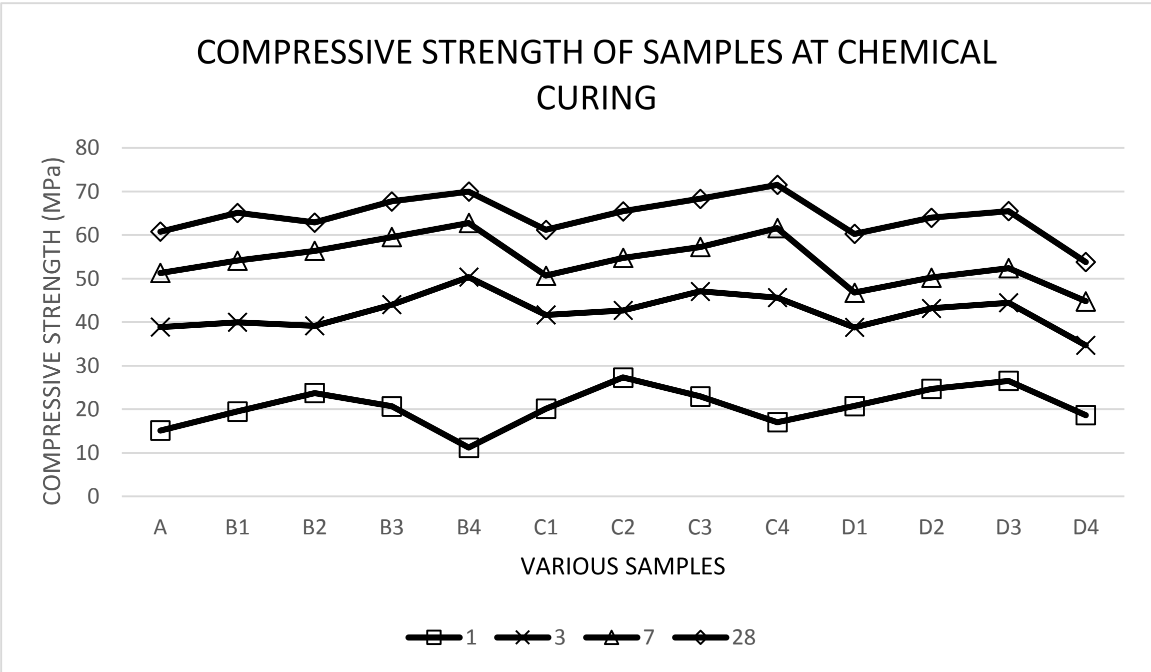

Figure 14. Influence of chemical curing of various sample

4. Conclusion

- The mix design formulated justifies the high early strength concrete and hence a well workable and durable concrete cast are obtained.
- The control sample gave the optimum slump and penetration resistance and 0.7% accelerator X, 0.65% of accelerator Y and 0.9% of accelerator Z satisfy the efficient requirement to be used in the industry.
- In terms of very early strength, the penetration resistance test, the major strength gain is observed in mixes with accelerator at early hours. Mix with type C accelerator resulted in 4 to 5% more gain than the mixes with type B and D accelerators.
- Adoption of chemical curing turned out to be more liable as most of the strength is gained within 7 days and additional curing is not required in normal temperature conditions.
- The chemical curing is better option in terms of strength gain as no extra effort is to be put after applying and is very efficient in term of industrial use.

5. References

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