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Effect of succinic acid on compression strength concrete material

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ABSTRACT

The aim of this research is to determine the effect of succinic acid on concrete strength. Butanedioic acid, also known as amber acid and succinic acid, is a 1, 2-ethanedicarboxylic acid. In nature, succinic acid is found in its pure or esterified forms. Maleic anhydride is converted to succinic acid through catalytic hydrogenation. Succinic acid is used as a construction additive. Succinic acid is applied to concrete at a concentration of 0 to 2% by weight. Succinic acid has a plasticizing effect. Compression intensity increased as succinic acid concentration increased. Succinic acid performs optimally at a concentration of 1% in M30, M25, and M20 concrete.

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1. Introduction

Concrete being basic in nature, is extraordinarily susceptible to acid attack. The mechanism for this process is very simple. In acid attack mechanism Ca $(OH)_2$ of cement react with acid and form salt of calcium as a byproduct which is soluble in water. By product calcium salts is eliminated by dissolving in water from the cement paste. This reaction of acid with Ca $(OH)_2$ is given as [1].

$$Acid + Ca(OH)_2 \rightarrow Calcium\ Salt\ +\ H_2O$$

In the agro-food and nuclear waste industries reaction of cement with short chain organic acid change the durability and structure but this can be used for improving the other properties of concrete like workability, strength etc.

Due to less negative effects of organic acids their salts are used in fresh or hardened concrete cement matrix to improve some properties. Acid cannot change the stability of calcium silicate hydrate gel and solubility of Ca-$C_4H_4O_4$ is a moderate [2,3].

The interactions mechanism of cement and organic acids is very intensive. The physical and chemical mechanisms of attack of organic acid have been investigated by experiment. Two types of acids have been used (i) organic acid which form soluble salt, like propionic acids, butyric acid and lactic acid (ii) organic acid which form insoluble salt, like tartaric acids oxalic, malic, and succinic [4,5]. The mechanisms of organic acid which form soluble salt is similar to mechanism of strong acid like HCl and HNO_3 [4,6,7]. The chemical and physical properties of organic acid which form insoluble salt change properties like volume, solubility etc [8].

2. Experimental program

2.1. Materials

2.1.1. Cement

Cement is a material which is a binder in nature which is used in construction for harden and setting with some other alternative materials by binding together. In this study 43 grade Ordinary Portland cement (OPC) was used.

2.1.2. Aggregates

Aggregates are those materials which provide volume, stability and wear resistance to the finished products. Aggregates which are used in concrete are of two types:

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(1) 10 mm fine aggregates consist of sand, very small gravel, crushed clinker.
(2) 20 mm coarse aggregates having gravel, small stone.

2.1.3. Additives

Additive is the artificial or natural materials which are added in concrete besides cement, aggregate and water to improve its properties. For improve the quality of concrete, chemical additive succinic acid is added during mixing. Succinic acid also works as plasticizer material.

2.2. Concrete mix design

The IS: 10262–2009 [9] code method of concrete mix design was used to design M30, M25 and M20 concrete. Mixing of components is done according to IS for M30, M25 & M20 concrete. The amount of additives is 0.5, 1.0, 1.5 and 2.0% by cement weight is added. The components of concrete are totally blended in mixer computing device until uniform consistency is obtained. Initially mould is greased with oil then the concrete is filled in iron mould after filling concrete is compacted by the vibrator. Now sample is removed from the iron mould after 1 day and then cured in water for a period of 7 and 28 days.

3. Experimental results and discussion

3.1. Concrete compression strength

Compression strength for concrete on 7th and 28th day with different proportion of succinic acid is presented in Table 1. In this

Table 1
M20 Concrete compression strength on 7th and 28th day at various proportion of Succinic acid.

S. No.	% of Succinic acid	7th day Compression strength (MPa)	28th day Compression strength (MPa)
1	0.0	20.33	28.45
2	0.5	20.95	28.40
3	1.0	21.75	30.22
4	1.5	21.45	28.50
5	2.0	19.25	27.40

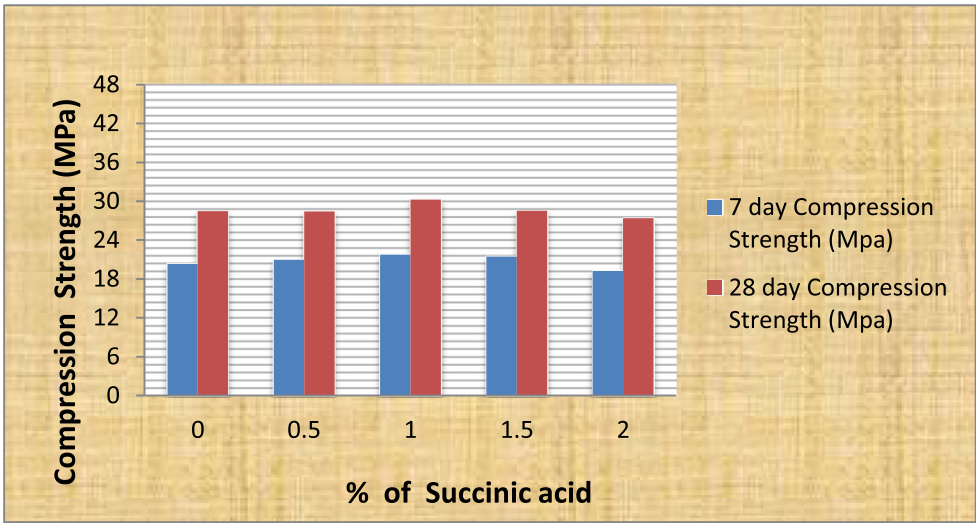

Fig. 1. M20 Concrete compression strength on 7th and 28th day at various proportion of Succinic acid.

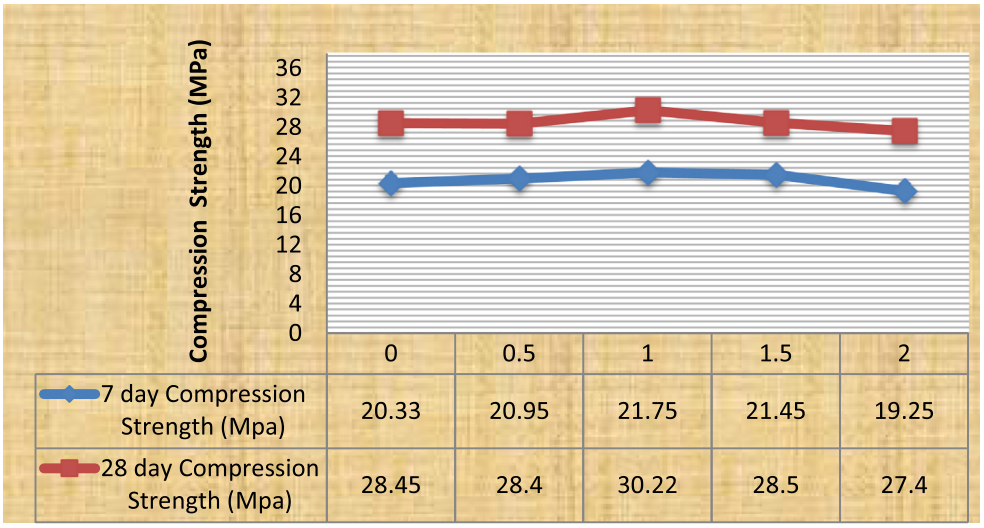

Fig. 2. Modification in Compression strength of M20 concrete on 7th and 28th day at various proportion of Succinic acid.

Table 2
M25 Concrete compression strength on 7th and 28th day at various proportion of Succinic acid.

S. No.	% of Succinic acid	7th day Compression strength (MPa)	28th day Compression strength (MPa)
1	0.0	25.68	36.36
2	0.5	26.55	36.95
3	1.0	28.85	37.85
4	1.5	27.45	36.75
5	2.0	26.02	35.60

study, Succinic acid was added up to 2% of the cement weight in M30, M25 and M20 Concrete. Fig. 1 shows the M20 Concrete compression strength on 7th and 28th day at various proportion of Succinic acid and Fig. 2 shows the Modification in Compression strength of M20 concrete on 7th and 28th day at various proportion of Succinic acid.Table 2.

Concrete compression strength on 7th day for M20 varied from 20.33 to 21.75 N/mm^2 with 0% to 1% concentration of the additive succinic acid and then decreased to 21.45 and 19.25 N/mm^2 with 1.5% and 2% respectively. Concrete compression strength on 28th day for M20 varied from 28.45 to 30.22 N/mm^2 with 0% to 1% concentration of the additives succinic acid and decreased to 28.50 and 27.40 N/mm^2 with 1.5% and 2% respectively. Table shows the M25 Concrete compression strength on 7th and 28th day at various proportion of Succinic acid.

Fig. 3 shows the M25 Concrete compression strength on 7th and 28th day at various proportion of Succinic acid and Fig. 4 shows the Modification in Compression strength of M25 concrete on 7th and 28th day at various proportion Succinic acid. Concrete compression strength on 7th day for M25 changed from 25.68 to 28.85 N/mm^2 with 0% to 1% concentration of the additives succinic acid and then decreased to 27.45 and 26.02 N/mm^2 with 1.5% and 2% respectively. Concrete compression strength on 28th day for M25 varied from 36.36 to 37.85 N/mm^2 with 0% to 1% concentration of the additives succinic acid and then decreased to 36.75 and 35.60 N/mm^2 with 1.5% and 2% respectively. Table 3 represent the M30 Concrete compression strength on 7th and 28th day at various proportion of Succinic acid.

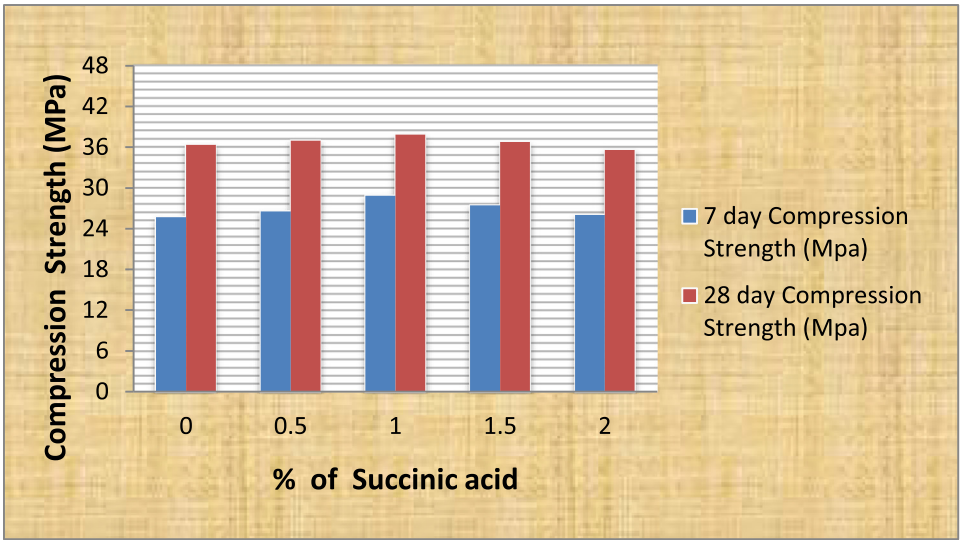

Fig. 3. M25 Concrete compression strength on 7th and 28th day at various proportion of Succinic acid.

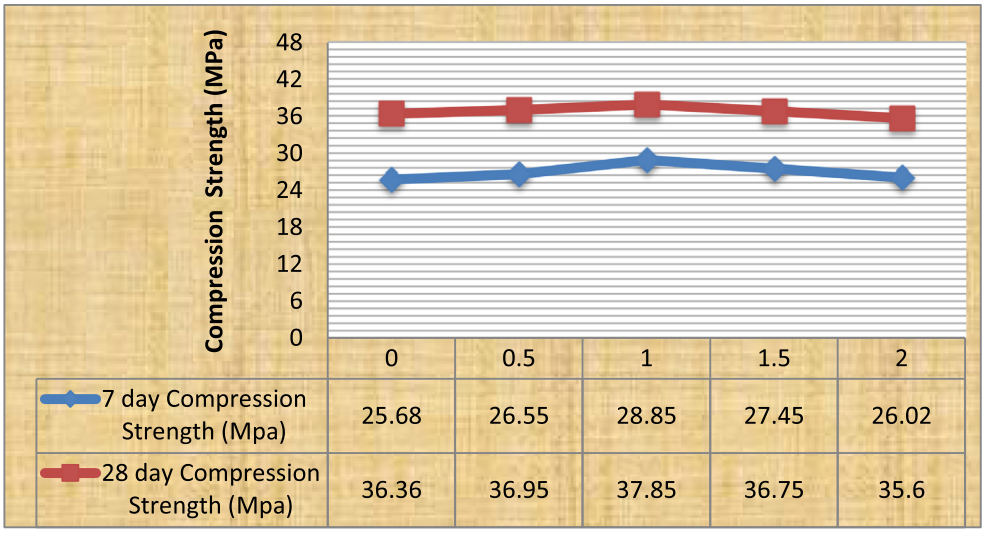

Fig. 4. Modification in Compression strength of M25 concrete on 7th and 28th day at various proportion Succinic acid.

Table 3
M30 Concrete compression strength on 7th and 28th day at various proportion of Succinic acid.

S. No.	% of Succinic acid	7th day Compression strength (MPa)	28th day Compression strength (MPa)
1	0.0	30.38	40.39
2	0.5	31.50	40.50
3	1.0	32.70	42.45
4	1.5	31.25	40.90
5	2.0	30.10	38.50

Fig. 5 shows the: M30 Concrete compression strength on 7th and 28th day at various proportion of Succinic acid and Fig. 6 shows the Modification in Compression strength of M30 concrete on 7th and 28th day at various proportion of Succinic acid. Concrete compression strength on 7th day for M30 changed from 30.38 to 32.7 N/mm^2 with 0% to 1% concentration of the additives succinic acid and then decreased to 31.25 and 30.10 N/mm^2 with 1.5% and 2% respectively. M30 Concrete compression strength on 28th day changed from 40.39 to 42.45 N/mm^2 with 0% to 1% concentration of the additives succinic acid and then decreased 40.90 and 38.50 N/mm^2 with 1.5% and 2% respectively.

4. Conclusion

Succinic acid worked as plasticizer and retarder. Succinic acid reacts with hydrated cement phases and affects structure durability and modifies cement properties. As the proportion of succinic acid from 0 to 2% increases, initially compression strength increased then decreased. Succinic acid gives optimum results with 1% addition for M30, M25 and M20 due to its reaction with extra lime and forms calcium succinate.

$$Succinic\ acid + CaO \rightarrow Calcium\ Succinate + H_2O$$

Use of succinic acid makes the concrete more workable, pumpable and placable and it is economically cheaper then cement based concrete.

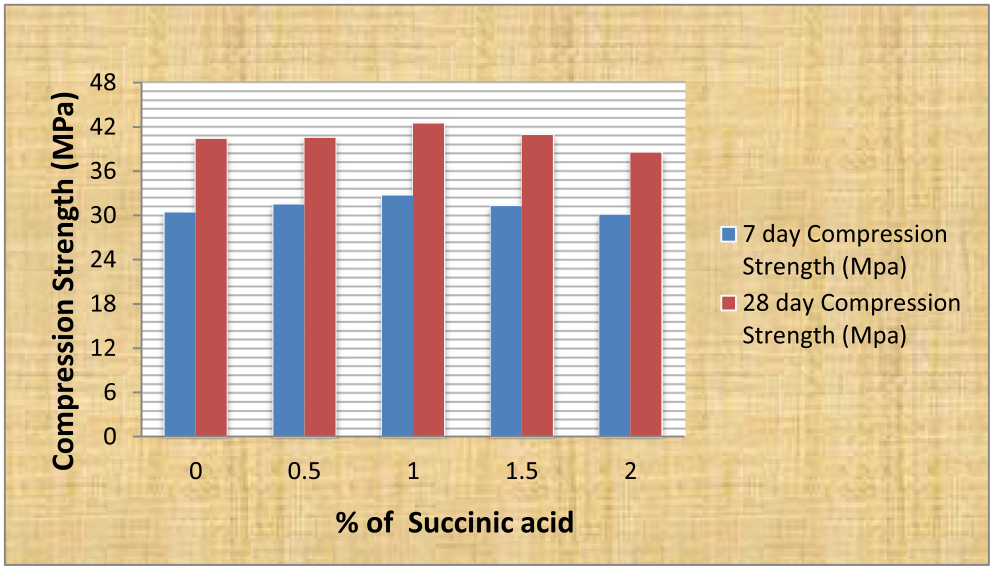

Fig. 5. M30 Concrete compression strength on 7th and 28th day at various proportion of Succinic acid.

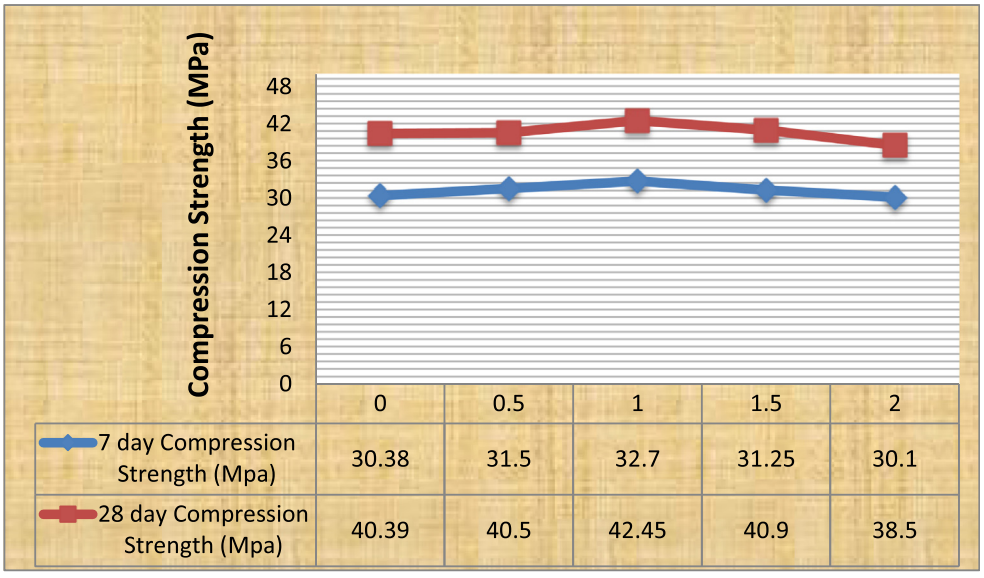

Fig. 6. Modification in Compression strength of M30 concrete on 7th and 28th day at various proportion of Succinic acid.

CRediT authorship contribution statement

Keshav Parashar: Investigation, Writing - original draft. **Dr. Rakesh kumar Dubey:** Conceptualization, Writing - review & editing, Supervision. **M. Padmaja:** Formal analysis, Data curation. **Khongdet Phasinam:** Conceptualization. **Dr. J. Tracy Tina Angelina:** Writing - review & editing. **Piyush Gupta:** Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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