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# Development of Normal Strength and High Strength Self Curing Concrete and Self Compacting Concrete Using Sodium Polyacrylate As A Polymer

**B. Naga Niranjan Kumar[1] R. V. Nagaraja Rao[2], G. Bhargav Kumar[3]**

Dr. K.V. S. R Institute of Technology, Kurnool, Andhra Pradesh, India

## ABSTRACT

The overall development of the country depends on infrastructure development for the uninterrupted progress of infrastructure availability of materials. In that materials water is the major material for the construction. Now a day's need of water is very high and availability is less. For that reason we use the polymers in the place of water. The main objective of the present study is to investigate a suitable combination of compressive strength self-curing concrete and self-compacting concrete with two different curing techniques. Curing is the most important step in concrete construction lack of curing has significant impact on concrete strength and durability self curing concrete is designed to hold water and reduce water evaporation while increasing water retention capacity .Hydrophilic water soluble polymers can be used as self curing agents in concrete as they can absorb water and keep the surrounding medium moist so that water present in that can be medium used for reaction of cement self curing concrete is also ideal further in hot weather regions where large quantities of water are needed for curing. Self compacting concrete is a type of concrete that gets compacted under it self-weight. The use of self compacting concrete is spreading worldwide because of its very attractive properties in the fresh state as well as after hardening. The use of self curing concrete will lead to more industrialized production .It reduce the cost of concrete in constructions and improve the quality, durability and reliability of concrete structure and eliminate some of the potential for human error. The present investigation focuses on the compressive behavior of concrete with different proportions of polymers and compactions.

**Keywords:** Sodium Polyacrylate, Polymer, SAP, LWA, PEG, SCC, SCLC

## I. INTRODUCTION

Sodium polyacrylate is used as a superabsorbent polymer in concrete. This study focused on the strength and shrinkage of concrete. If we concluded that the shrinkage of concrete due to loss of water to the surroundings is the cause of cracking both in the plastic and in the hardened stage. This type of cracking can effectively mitigated by slowing down the water loss. The superabsorbent polymers use in concrete has the potential to reduce concrete cracking.

They concluded that the autogenous shrinkage may lead to cracking and affect concrete strength and durability, which is also, can be considered as technological challenge of high performance concrete. Addition of superabsorbent polymer in the ultra-high-performance concrete can be used to control the autogenous shrinkage. They also conducted tests that show that the shrinkage reduction due to superabsorbent polymer. We studied the use of Sodium Polyacrylates as SAP in concrete. The study focused on determining the optimum amount of SAP to be added to the concrete in order to maximize the strength and durability of concrete. We concluded in his study that the optimum amount of SAP is 0.11 percent of cement by weight, which he showed to be the most effective amount to be used in concrete.

An experimental study is conducted on lime powder produced from lime industry is mixed with cement concrete in partial replacement of cement. Normal strength grade concrete of M30 design mix with various percentages of lime powder and polymer replacing cement has been made use in the investigation. Experimental study is carried out to investigate the

compressive strength of concrete with replacement of cement by polymer and lime powder.

## II. METHODS AND MATERIAL

### 1. Literature

Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation. There are two major methods available for internal curing of concrete. The first method uses saturated porous lightweight aggregate (LWA) in order to supply an internal source of water, which can replace the water consumed by chemical shrinkage during cement hydration. The second method uses poly-ethylene glycol (PEG) which reduces the evaporation of water from the surface of concrete and also helps in water retention. In the present study the first method is being adopted. The use of fly ash, blast furnace slag and silica fume in SCC reduces the dosage of superplasticizer needed to obtain similar slump flow compared to concrete mixes made with only Portland cement.

Objectives

Therefore, main objectives of the present work is

- To study the possibility to incorporate lime powder waste as a replacement of cement in addition to polymers.
- The other objectives of this work was to determine under what condition the lime powder in conjunctions with Sodium polyacrylate and plasticizer increases the strength of concrete when these are used as partial replacement materials of cement.
- To determine the degree of strength improvement in concrete with addition of lime stone powder

### 2. Proposal

- In this present work, it is aimed at developing a new building material from the lime scrap, an industrial waste as a replacement material of sodium polyacrylate and partial replacement of cement. Moreover, Sodium polyacrylate is very expensive wasting a very expensive material is not good engineering practice and hence Sodium polyacrylate is replaced by some amount of lime waste in certain percentages. By doing so, the objective of reduction of cost construction can be met and it will help to overcome the environmental problem associated with its disposal including the environmental problems of the region.

A. Materials used in this experiment

1) Cement

Ordinary Portland cement 53 grade Dalmia Brand conforming to B.I.S standards is used in the present investigations. The cement is tested for its various properties as per IS 4031-1988 and found to be conforming to the requirements as per IS 8122-1989 are shown in Table 1.

**Table 1:** Properties of cement

| Physical properties | Results |
|---|---|
| Fineness | 2% |
| Normal consistency | 30% |
| Vicat initial setting time(minutes) | 30 |
| Vicatfinal setting time (minutes) | 204 |
| Specific gravity | 3.12 |

### 3. Polymers

Chain of monomers are called Polymers.
Generally, polymers are used in Self curing concrete are Sodium polyacrylate, Polyethylene Glycol, Polyacrylamide.

### 4. Sodium Polyacrlate

Sodium polyacrylate, also known as waterlock, is a sodium salt of polyacrylic acid with the chemical formula [-CH2-CH(COONa)-]n and broad application in consumer products.

It has the ability to absorb as much as 200 to 300 times its mass in water. Sodium polyacrylate is anionic polyelectrolytes with negatively charged carboxylic groups in the main chain.

Sodium polyacrylate is a chemical polymer that is widely used in a variety of consumer products for its ability to absorb several hundred times its mass in water. Sodium polyacrylate is made up of multiple chains of acrylate compounds that possess a positive anionic charge, which attracts water-based molecules to combine with it, making sodium polyacrylate a super-absorbent compound. Sodium polyacrylate is used extensively in the agricultural industry and is infused in the soil of many potted plants to help them retain moisture, behaving as a type of water reservoir. Florists commonly use sodium polyacrylate to help keep flowers fresh. For fast absorption a slight increase of sodium polyacrylate can be used for demonstration purposes.

Molecular Formula:
[-CH2-CH(COONa)-]n
• Properties:
Appearance - Clear Liquid
Specific Gravity - Approx 1,2 g.cm-3
pH(10%) - 5-6
Non volatile Content - 41%
Ion Character - Anionic

Detailed technical data sheet is available upon request.

• Description:

Sodium polyacrylate is commonly used as a dispersing agent for pigments and aqueous systems and is effective at a wide pH range, with low foaming properties and compatibility with all synthetic emulsion.

Applications:
- Highly effective dispersant for inorganic pigments, fillers, detergents and water treatments.
- Real quantity depends on the type and the quantity of the pigments used in emulsion.
- Eliminates the formation of deposits of inorganic salts in aqueous systems. Used as anti re-deposition agent for detergents.
- Used as an antiscalant at boiler and cooling water treatments to reduce scale formation and improves the efficiency.
- It is used for binding multivalent metal ions and keep them in solution.
- Can be used alone or combination of phosphanetes.
- Used to remove soil from substrate and stabilize them in bath.
- Enhances the efficiency of pigment printing paste due to the elimination of water hardness.

3) Aggregates

Locally available natural sand with 4.75 mm maximum size was used as fine aggregate(FA). Coarse aggregate (CA) of maximum 12.5 mm was used. Table-3 gives the Physical properties of fine & coarse aggregate.
4) Super Plasticizer (SP)

Master glenium-Ace 30(JP) from BASF Bangalore was used.

**Table 1**

| Property | Fine(FA) | Coarse(CA) |
|---|---|---|
| Specific gravity | 2.51 | 3.1 |
| Fineness modulus | 3.37 | 7.1 |
| Surface texture | Smooth | -- |
| Particle shape | Rounded | Angular |
| Crushing value | -- | 17.4 |
| Impactvalue | -- | 12.5 |

## 5. Lime Stone Powder

A high quality lime stone powder generally permits a reduction in water content of a concrete mixture, without loss of workability. Lime stone powder obtained from India's cement Limited, Tirunelveli was used for the study. Specific gravity of Lime stone powder used was 1.39.

Limestone is used in virtually all construction materials. Limestone is added in with clay and heated to form cement, which can be made into mortar by adding sand and water. Mortar is used to set bricks and act as an adhesive when it dries. Limestone is also used in concrete and asphalt filler.

**Table 2**

| Physical Properties | |
|---|---|
| color | White |
| Streak | White |
| Sparkle | Glass |
| Hardness | 3-4 |
| Cracking | In three directions |
| Water absorption | Less than 1% |
| porosity | Low |
| Stress pressure | 1800-2100 Kg/cm2 |
| Specific Gravity | 2.5-2.65 Kg/ cm |

The very pure limestone located in Sammalut formation Elminea governorate 200 km south Cairo, this formation has the high purity due to the microfossiles which lived in the past on the marine environment ( biological depositions).

Physical properties and chemical composition of Lime stone powder

**Table 3**

| Chemical | Percentage (%) |
|---|---|
| Caco3 | 99.5 |
| Mgo2 | 0.01 |
| Sio2 | 0.3 |
| Fe2O3 | 0.01 |
| Al2O3 | 0.01 |
| Loss of ignition | 43.89 |

## Clinkers

- The incombustible residue, fused into an irregular lump,that remains after the combustion of coal.
- A mass of incombustible matter fused together, as in the burning of coal.
- A clinker is an incombustible fragment that can be found in ash residue after burning heating fuels such as coal or wood.
  Industrial Crushers reduce large rocks into smaller rocks, gravel, or rock dust. Crushers may be used to reduce the size, or change the form, of waste materials so they can be more easily disposed of or recycled, or to reduce the size of a solid mix.

7) Water

Ordinary portable water is used.

B.Mix design

Replacement of cement by Sodium polyacrylate

**Table 4**

| Mix design | Nominal mix | mix-1 | mix-2 | mix-3 |
|---|---|---|---|---|
| %replacement of sodium polyacrylate | 0 | 0.1 | 0.2 | 0.3 |
| w/c ratio | 0.39 | 0.39 | 0.39 | 0.39 |
| Cement content(kg) | 1.9 | 1.89 | 1.89 | 1.89 |
| Fine aggregate(kg) | 2.16 | 2.16 | 2.16 | 2.16 |
| Coarse aggregate | 4.30 | 4.30 | 4.30 | 4.30 |
| Water(lit) | 0.712 | 0.712 | 0.712 | 0.712 |
| Compressive strength 28days(N/mm2) | 35.8 | 42.2 | 43.7 | 44.8 |

Replacement of cement by Lime stone powder, Clinkers and Super plasticizer

**Table 4**

| Mix design | Nominal mix | mix -1 | mix-2 | mix-3 | mix-4 |
|---|---|---|---|---|---|
| %replacement of Lime stone powder | 0 | 5 | 10 | 15 | 20 |
| w/c ratio | 0.39 | 0.39 | 0.39 | 0.39 | 0.39 |
| Cement content(kg) | 1.35 | 1.28 | 1.21 | 1.14 | 1.08 |
| Fine aggregate(kg) | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Coarse aggregate | 4.94 | 4.69 | 4.44 | 4.19 | 3.95 |
| Water(lit) | 0.525 | 0.525 | 0.525 | 0.525 | 0.525 |
| Plasticizer (lit) | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 |
| Lime stone powder(g) | 33.75 | 67.5 | 135 | 202.5 | 270 |
| Clinkers (g) | 123.5 | 247 | 494 | 741 | 988 |
| Compressive strength 28days (N/mm2) | 36.2 | 43.1 | 44.5 | 45.6 | 38.1 |

## III. RESULTS AND DISCUSSION

This chapter consists of test results and discussions on workability, compressive strength, split tensile strength Self compacting self curing Concrete (SCLC) for different %polymers replacement levels. The test results are compared with Normal Self compacting Concrete (NC).

**Replacement of cement by Sodium Polyacrylate**

(a) Influence of sodium polyacrylate on compression strength
Compressive strength Vs % of cement replacement by Sodium polyacrylate

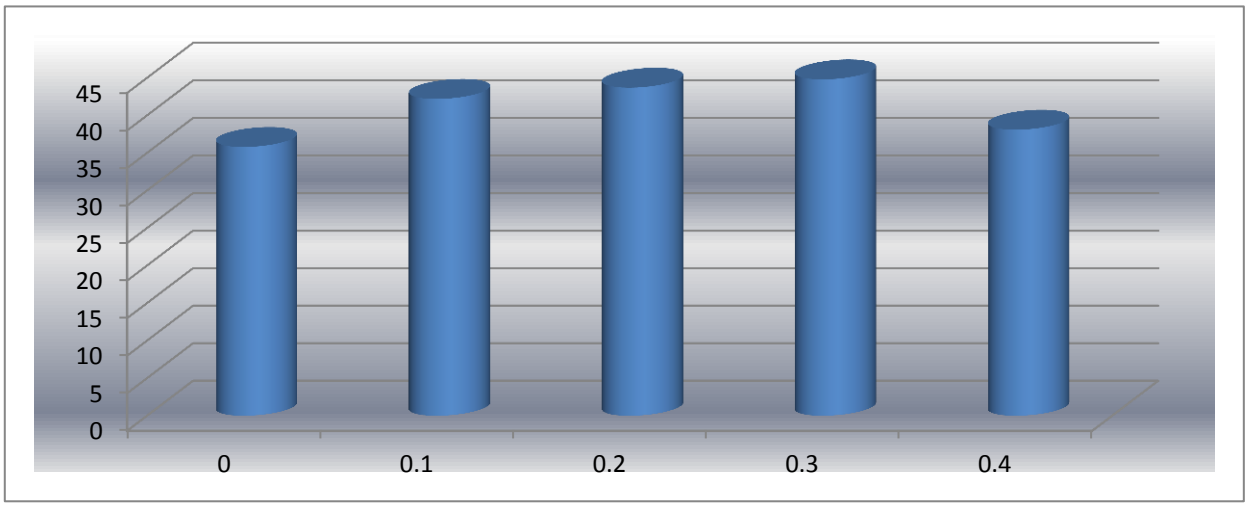


**Figure 1.** Compressive strength Vs %of cement replacement by Sodium polyacrylate

**Table 5**

| S.NO | %Replacement of cement with sodium polyacrylate | Compressive strength in (N/mm2) | % increase in strength |
|---|---|---|---|
| 1 | 0 | 35.8 | _ |
| 2 | 0.1 | 42.2 | 17.87 |
| 3 | 0.2 | 43.7 | 22.06 |
| 4 | 0.3 | 44.8 | 25.13 |
| 5 | 0.4 | 38.1 | 6.42 |
| 6 | 0.5 | 36.2 | 1.11 |
| 7 | 0.6 | 34.2 | _ |

In the present investigation sodium polyacrylate has been used as replacement of cement up to a maximum of 0.5%. The compressive strength for different percentage of sodium polyacrylate and percentage increase or decrease in strengths with respect to M30 grade concrete listed in the table. By taking normal M30 grade as referring percentage, percentage of increase or decrease in compressive strength other percentage is calculated. Considering the normal M30 with zero percentage admixtures the compressive strength is 35.8 N/mm2. When 0.1% replacement is used, the compressive strength is 42.2 N/mm2. Considering 0.2% replacement, the compressive strength is 43.7 N/mm2. And there is an increase in the strength 22.06 N/mm2. With 0.3% replacement, the compressive strength is 44.8 Nimm2 and there is a increase in strength 25.13 N/mm2. With 0.4% replacement, the compressive strength is 38.1 and there is a little increase in the strength. However, 0.4% can be taken as optimum dosage which can be mixed in cement concrete for giving optimum possible compressive strength at any stage.

**Replacement of cement by Lime stone powder, Clinkers and Super plasticizer**

(b) Influence of Lime stone powder, Clinker and Super plasticizer on compression strength

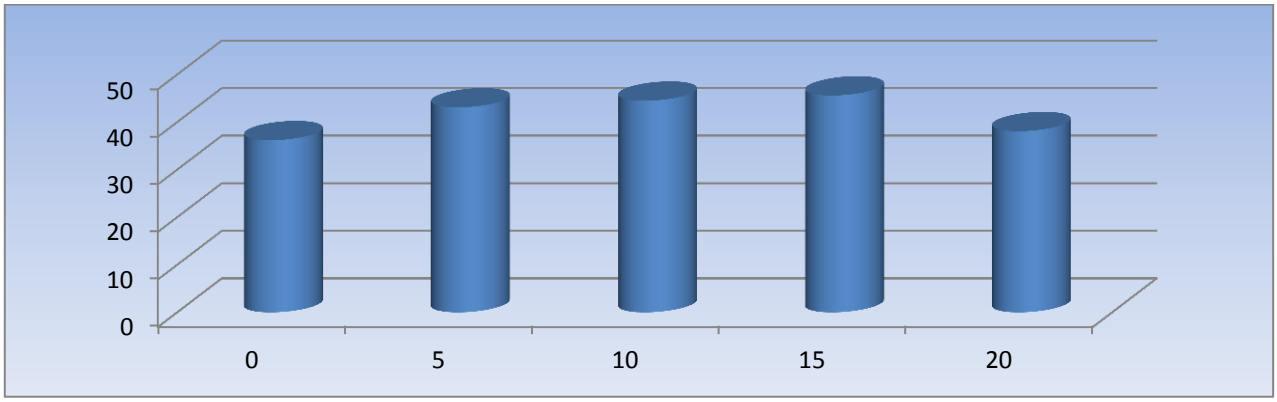


**Figure 2.**

**Table 6.** Compressive strength of Lime stone powder, Clinkers and Super plasticizer

| S.NO | % Replacement of cement with Lime stone powder | Compressive strength in (N/mm2) | % increase in strength |
|---|---|---|---|
| 1 | 0 | 36.2 | _ |
| 2 | 5 | 43.1 | 19.06 |
| 3 | 10 | 44.5 | 22.92 |
| 4 | 15 | 45.6 | 25.96 |
| 5 | 20 | 38.1 | 5.24 |

In the present investigation Lime stone powder has been used as replacement of cement up to a maximum of 20%. The compressive strength for different percentage of sodium poly acrylate and percentage increase or decrease in strength with respect to M30 grade concrete listed in the table. By taking normal M30 grade as referring percentage, percentage of increase or decrease in compressive strength other percentage is calculated. Considering the normal M30 grade with zero percentage admixtures the compressive strength is 36.2N/mm2. When 5% replacement is used, the compressive strength is 43.1 N/mm2 and increase in strength is 19.06 N/mm2. Considering 10% replacement, the compressive strength is 44.5N/mm2. And there is an increase in the strength is 22.92 N/mm2. With 15% replacement, the compressive strength is 45.6 N/mm2 and there is a increase in strength 25.96 N/mm2 .With 20% replacement, the compressive strength is 38.1 and there is a little increase in the strength. However, 15% can be taken as optimum dosage which can be mixed in cement concrete for giving optimum possible compressive strength at any stage.

**Table 7.** Split Tensile Strength

| Mix design | Nominalmix | mix-1 | mix-2 | mix-3 | mix-4 |
|---|---|---|---|---|---|
| %replacement or addition | 0 | 3+2=5 | 6+4=10 | 9+6=15 | 12+8=20 |
| w/c ratio | 0.39 | 0.39 | 0.39 | 0.39 | 0.39 |
| Cement content (kg) | 2.28 | 2.16 | 2.05 | 1.93 | 1.82 |
| Fine aggregate(kg) | 4.19 | 4.19 | 4.19 | 4.19 | 4.19 |
| Coarse aggregate | 8.31 | 8.31 | 8.31 | 8.31 | 8.31 |
| Water(lit) | 0.882 | 0.882 | 0.882 | 0.882 | 0.882 |
| Plasticizer(lit) | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 |
| Split tensile strength ($N/mm^2$) Sodium polyacrylate | 2.43 | 2.83 | 3.56 | 2.65 | 2.15 |
| Split tensile strength ($N/mm^2$) limstonepowder | 2.43 | 2.95 | 3.43 | 2.75 | 2.27 |
| Split tensile strength of (Sodium polyacrylate and lime stone powder) replacement($N/mm^2$) | 2.43 | 3.12 | 3.33 | 2.86 | 2.31 |
| Split tensile strength of (Sodium polyacrylate and lime stone powder) ($N/mm^2$) addition | 2.43 | 3.22 | 3.56 | 2.94 | 2.52 |

(c) Influence of both Sodium polyacrylate and lime stone powder on split tensile strength

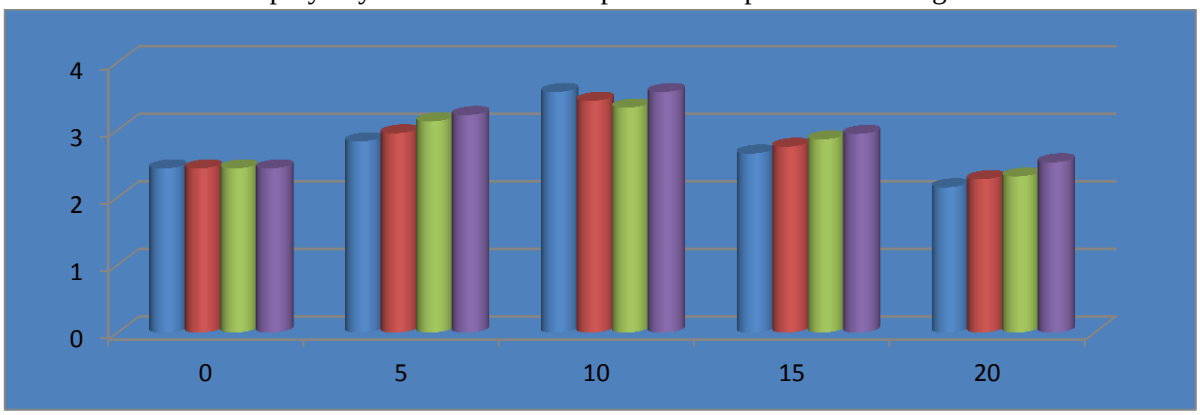


**Figure 3.** Split tensile Strength Vs % of combination of sodium polyacrylate and lime stone powder

**Table 8.** Split tensile strength of both sodium polyacrylate and lime stone powder

| S.NO | %age both sodium polyacrylate and lime stone powder | Sodium polyacrylate | Lime stone powder | Replacement of (S+L) | Addition of (S+L) |
|---|---|---|---|---|---|
| 1 | 0 | 2.43 | 2.43 | 2.43 | 2.43 |
| 2 | 5 | 2.83 | 2.95 | 3.125 | 3.22 |
| 3 | 10 | 3.56 | 3.43 | 3.33 | 3.56 |
| 4 | 15 | 2.65 | 2.75 | 2.86 | 2.94 |
| 5 | 20 | 2.15 | 2.27 | 2.31 | 2.52 |

**Table 8**

| Mix design | Nominalmix | mix-1 | mix-2 | mix-3 |
|---|---|---|---|---|
| %replacement or addition | 0 | 3+2=5 | 6+4=10 | 9+6=15 |
| w/c ratio | 0.39 | 0.39 | 0.39 | 0.39 |
| Cement content (kg) | 2.28 | 2.16 | 2.05 | 1.93 |
| Fine aggregate(kg) | 4.19 | 4.19 | 4.19 | 4.19 |
| Coarse aggregate | 8.31 | 8.31 | 8.31 | 8.31 |
| Water(lit) | 0.882 | 0.882 | 0.882 | 0.882 |
| Plasticizer(lit) | 0.045 | 0.045 | 0.045 | 0.045 |
| Split tensile strength ($N/mm^2$) Sodium polyacrylate | 2.43 | 2.83 | 3.56 | 2.65 |
| Split tensile strength ($N/mm^2$) limstonepowder | 2.43 | 2.95 | 3.43 | 2.75 |

**Flexural Strength**

(d) Influence of both sodium polyacrylate and lime stone powder on flexural tensile strength
Flexural tensile strength Vs % of both sodium polyacrylate and granite powder

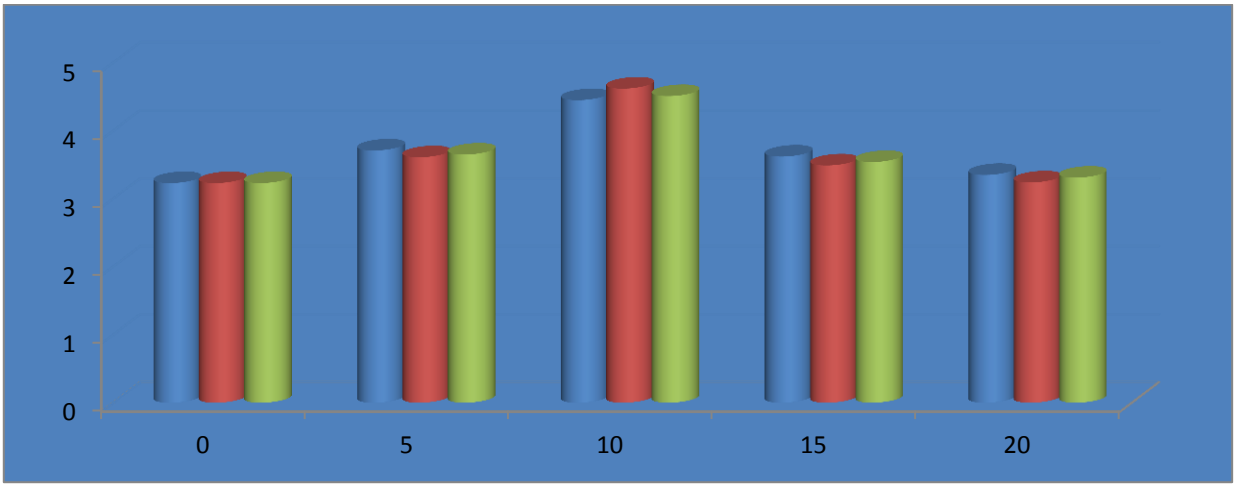


**Figure 4.** Flexural strength Vs% of combination of sodium polyacrylate and lime stone powder

**Table 9.** Flexural strength of both sodium polyacrylate and lime stone powder

| S.NO | %age both sodium polyacrylate and lime stone powder | Sodium polyacrylate | Lime stone powder | Replacement of (S+L) | Addition of (S+L) |
|---|---|---|---|---|---|
| 1 | 0 | 3.23 | 3.23 | 3.23 | 3.23 |
| 2 | 5 | 3.71 | 3.61 | 3.65 | 3.94 |
| 3 | 10 | 4.45 | 4.62 | 4.51 | 4.81 |
| 4 | 15 | 3.62 | 3.49 | 3.54 | 3.72 |
| 5 | 20 | 3.35 | 3.24 | 3.31 | 3.34 |

## IV. CONCLUSION

Based on limited experimental investigations conducted the following Conclusions are made

- From observations it can be concluded that Lime stone powder as a substitute giving better strength than Sodium polyacrylate or a Combination of Sodium polyacrylate and Lime stone powder.
- With partial replacement of 0-15% of Lime stone powder by cement the compressive strength increases.
- It may be economical by using Lime stone powder instead of Sodium poly acrylate, Since Sodium Polyacrylate is a costliest material.

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