Effect Of Concentration Of Sodium Hydroxide On Strength Of Geopolymer Concrete

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Abstract─ The objective of this work is to produce a carbon dioxide emission free cementious material. In this present study the main limitations of fly ash based geopolymer concrete are slow setting of concrete at ambient temperature and the necessity of heat curing are eliminated by addition of Ground Granulated Blast Furnace Slag (GGBS) powder which shows considerable gain in strength. The Alkaline liquids used in this study for the polymerization process are the solutions of sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3). The 8 and 10 Molarity solutions are considered to prepare the mix. The cube compressive strength was calculated for 8M and 10M solutions for different mix. Ambient curing of concrete at room temperature was adopted. The alkaline solution used for present study is the combination of Sodium silicate and Sodium hydroxide solution with the ratio of 2.5 .The freshly prepared geopolymer mixes are cohesive and their workability is increased with the increase in the ratio of alkaline solution.
Keywords- Flyash, GGBS, Geopolymer concrete, Sodium hydroxide, Sodium silicate, Molarity

1. INTRODUCTION

Geopolymer concrete (GPC) are a type of inorganic polymer composites, to form a substantial element of an environmentally sustainable construction and building products industry by replacing/supplementing the conventional concretes. The geo-polymer term was introduced by Davidovitsin 1970s to name the three dimensional alumino-silicates material, which is a binder produced from the reaction of a source material or feedstock rich in silicon and aluminium with a concentrated alkaline solution. The source materials may be industry waste products such as fly ash, silica fume, red mud, rice-husk ash and slag may be used as feedstock for the synthesis of geopolymers. The alkaline liquids are concentrated aqueous alkali hydroxide or silicate solution, with soluble alkali metals, usually Sodium-(Na) or Potassium-(K) based.

While forming the geopolymer, alumina-silicate materials dissolved into alkali solution to form free silicon tetraoxide and aluminium tetraoxidetetrahedral units. Further these silicon tetraoxideand aluminium tetraoxide tetrahedrons are linked alternatively. Mainly it contains silicon dioxide and aluminium oxide along with other compounds like calcium oxide, iron oxide, magnesium oxide, manganese oxide etc. Because of easy availability, alumina-silicate composition, high workability, desired strength and low water demand, flyash became the material of interest for geopolymer synthesis. During the process of geopolymerisation, silicon in the flyash reacts with alkaline solution, which forms the cementatious material The important limiting factor of using this flyash based geopolymer concrete is low reactivity, which results in slow setting time and takes more time to attain required strength. In some cases the dissolution of flyash is not completed before the final hardened structure is formed.

Coal ash which is the waste residue from thermal power plant, which produces large quantity of coal ash throughout the world. It is estimated that around 600MT/year of coal is producing currently. In that coal ash, flyash constitutes 75% to 80% of total ash produced. Thus the quantity of flyash produced by these thermal power plants increasing every year throughout the world. So it is necessary to dispose this flyash safe and environment friendly. In India the utilization of flyash is very less compared to advanced countries.

The present study deals with the role of GGBS in the percentile replacement of fly ash on the mechanical properties of the GPC. GGBS consists of silicon dioxide, calcium oxide, aluminium oxide and magnesium oxide. It is a by-product of manufacturing process of iron. The problem of low reactivity of flyash can be eliminated by the adding of GGBS.

The main objective of the present study is

- To develop the structural grade geopolymer concrete with different percentage of flyash and GGBS.
- To know the effect of concentration of alkaline solutionsi.e. 8M and 10M Sodium hydroxide
- To determine the compressive strength, split tensile strength and flexural strength of GPC.

2. MATERIALS USED

FLYASH

Generally coal based thermal power plant produces two types of ash i.e flyash and bottom ash in the combustion process. Flyash is the small fraction of ash carried by flue gas and is collected from the electrostatic precipitators of thermal power plants. Most of flyash particles are spherical in shape whose size ranges from 0.5μ to 100μ. According to ASTM C618 70% to 80% is constituted by low lime flyash in the total production of coal ash which generally comes under flyash class F.

GROUND GRANULATED BLAST FURNASE SLAG (GGBS)

It is a by-product obtained in the manufacture of iron and slag. Here limestone, iron ore and coke are filled into the furnace and the resulting slag of molten form will float above the molten iron at temperature of 1500°c to 1600°c. The slag which contains mainly siliceous and aluminous residue can be obtained by tapping from the molten iron. Then this slag should be quenched by water to get the glassy granulate. This material is dried and ground into the required size which is called as Ground Granulated Blast Furnace Slag.

COARSE AGGREGATE

Coarse aggregates are boulders, granite chips, natural stones etc. In the process of sieve analysis the material which retains on IS Sieve of 4.75mm are called coarse aggregate. Generally broken hard stone is used as coarse aggregate. The type of work decides the size of aggregates. For example thin slabs require small size coarse aggregates. The aggregates which are used for the geopolymer concrete should be hard, durable and clean. It should be free from clay and other natural impurities. The presence of above substances avoids the binding capacity between aggregates and binding material. Coarse aggregate of size 12mm and 20mm are used in the present study.

FINE AGGREGATE

The material which passes through IS sieve of 4.75mm size are called fine aggregate. Fine aggregate should consist of natural sand or crushed sand. In the present study, river sand was used. The required properties of fine aggregates are, it should be hard, durable, clean and also free from impurities. The silt content should not exceed 4%.

PHYSICAL PROPERTIES OF MATERIALS

SL NO	DESCRIPTIONS	FLYASH	GGBS	FINE AGGREGATE	COARSE AGGREGATE
1	Specific gravity	1.84	2.6	2.6	2.74
2	Fineness	8%	2%	−	−
3	Moisture content	−	−	6.06%	0.5%
4	Bulk density	−	−	−	1370.55Kg/m^3
5	Silt content	−	−	6.2%	−

SODIUM HYDROXIDE SOLUTION

The commonly used alkaline activator in geopolymer concrete is combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate. The type and concentration of solution affect the dissolution of flyash. Leaching of Al^{+3} and Si^{+4} ions is generally high with NaOH solution compared to KOH solution. Hence, alkali concentration is important factor in controlling the leaching of alumina and silica from flyash particles subsequent geopolymerisation and the strength property of hardened geopolymer concrete.

SODIUM SILICATE

Activators play important role in the geopolymerization process. Reactions occur at high rate when alkaline activator contains soluble silicate.

SUPER PLASTICIZER

It is a chloride free super plasticizer and is selected from sulphonated naphthalene polymers. This is in the form of solution which instantly disperses in water. The CONPLAST SP430 provides high workability, usually it is necessary in pumping the concrete for high rise structures and also provide early strength. It is available in 5, 20 and 200 litre drums. This super plasticizer is non-toxic and non flammable.

3. METHODOLOGY

Preparation of Alkaline solution

The molecular weight of sodium hydroxide is 40. To prepare 8M sodium hydroxide solution 320gm of NaOH flakes are weighed and they can be dissolved in distilled water to form one litre solution. For this, volumetric flask of one litre capacity is taken NaOH flakes added slowly to distilled water which is in the volumetric flask.

Mixing of Geopolymer concrete

The flyash, GGBS, fine aggregates and coarse aggregate were mixed in a container. After thorough dry mixing, the alkaline solution was poured in to the dry mix. Again it is mixed along with super plasticizer. Mixing was done by hand. So it is necessary to mix the concrete properly in order to have a uniform distribution of ingredients. The mix is done for about 10minutes for proper bonding of all ingredients. This mixed concrete is to be filled into 150mm cubes, 150mm×300mm cylinders and 100mm×100mm×500mm prisms. As there is no code provision for mix design of geopolymer concrete, the density of geopolymer concrete is assumed as 2440Kg/m^3 and designed accordingly.

Casting

After proper mixing, the concrete should be poured into the moulds of required shape and size. Before this the moulds should be oiled. Here we used 150mm cube, 150mm×300mm cylinder and 100mm×100mm×500mm prism. After pouring of concrete to moulds, the concrete should compact thoroughly by hand with tamping rod. This can be done by making in to three layers. Each layer should be tamped for about 50 blows from tamping rod. Then the top face should be finished well to get smooth surface. Then keep it for about 24hrs for demoulding.

Curing

The geopolymer concrete moulds should be placed in the direct sunlight after demoulding. The tests were conducted for 7days and 28 days. For sunlight curing, the cubes are to be demoulded after one day of casting.

4. RESULTS

In this section, the experimental results are presented and discussed. In the presnt study four different mixes were prepared by increasing the percentage of GGBS and tests were conducted for all the specimens. All the test results are shown in the graphs. All the three tests were conducted for 7days and 28days.

COMPRESSION TEST

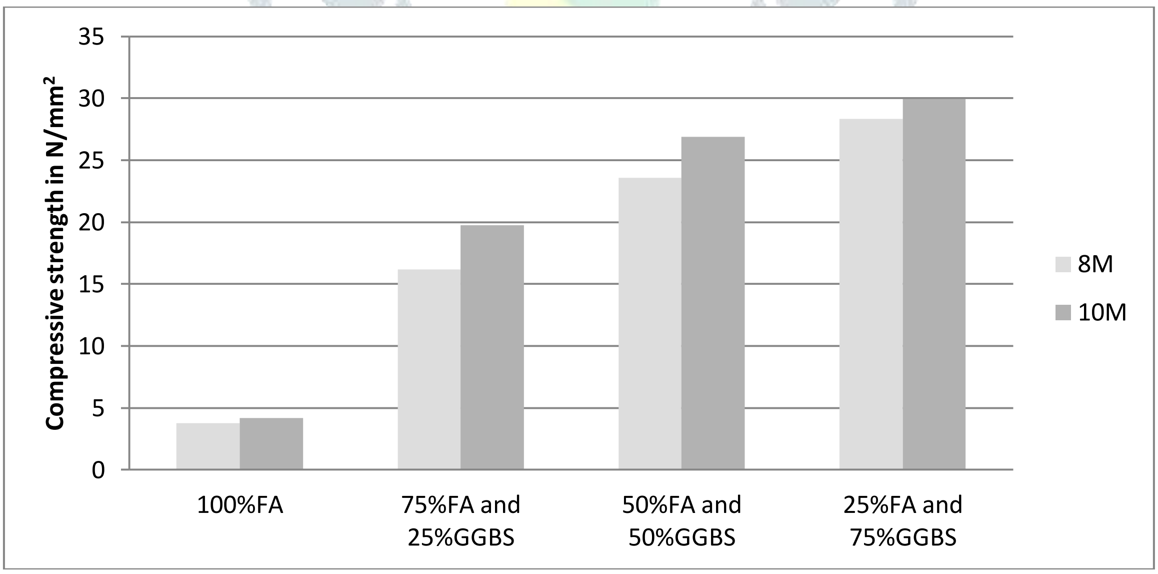

Fig 1 Variation of compressive strength on varying molarity and GGBS content for 7days

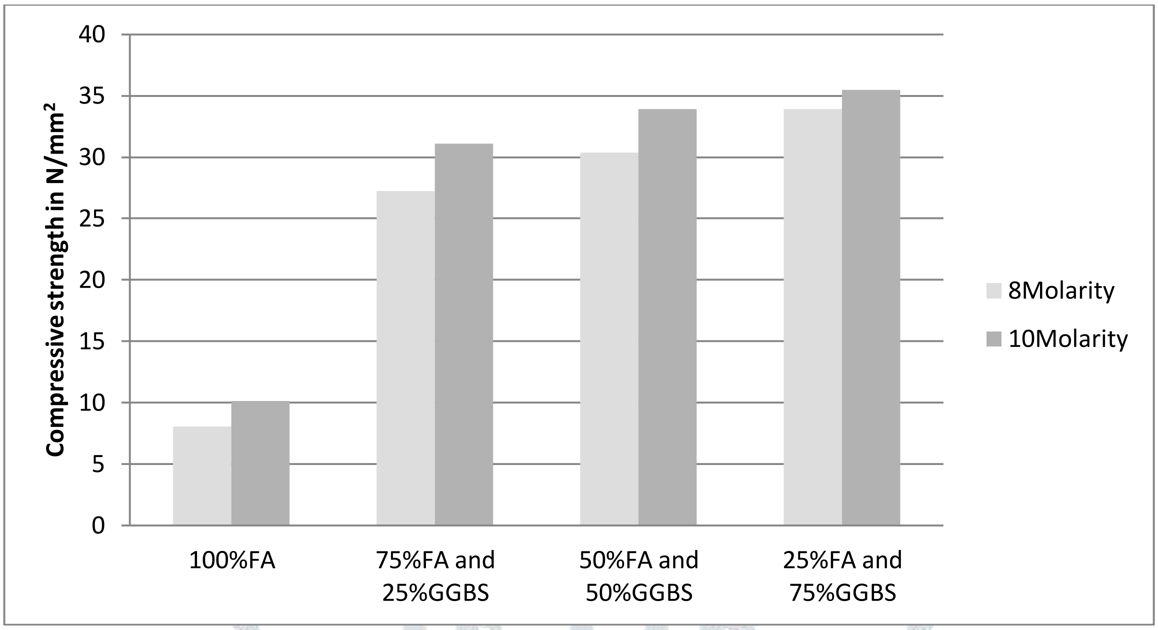

Fig 2 Variation of compressive strength on varying molarity and GGBS content for 28days

The above bar chart reveals that the compressive strength of GPC increases with increase in the concentration of sodium hydroxide and increase in the amount of GGBS added.

SPLIT TENSILE STRENGTH

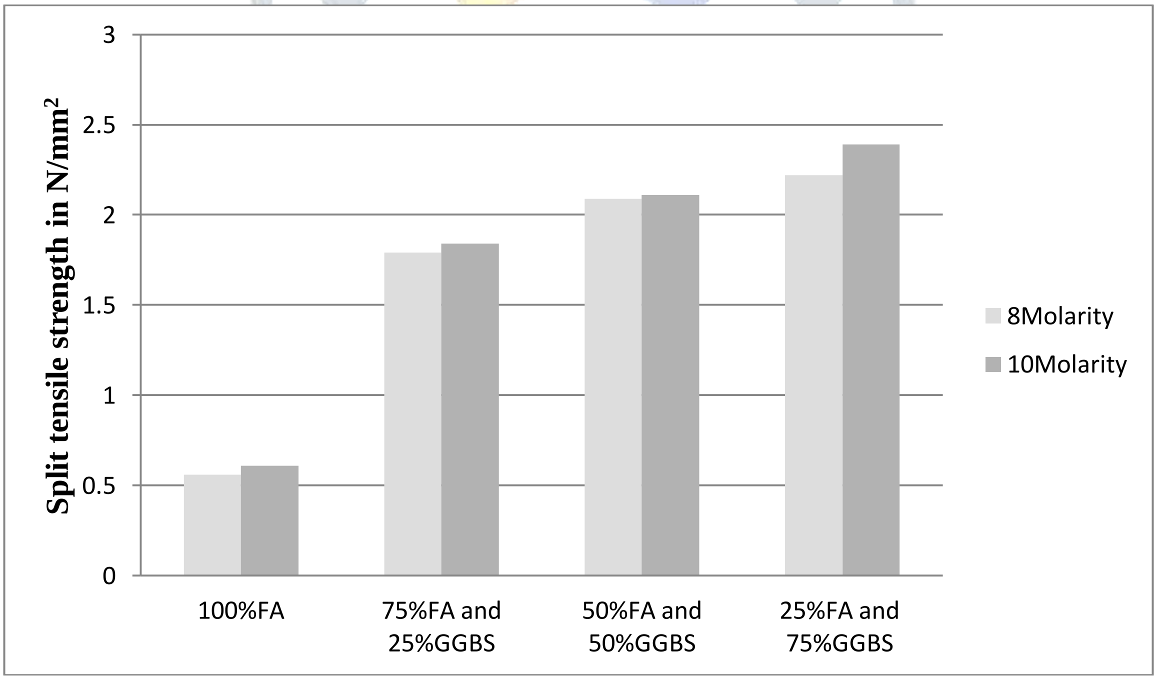

Fig 3 Split tensile strength on varying molarity for 7days

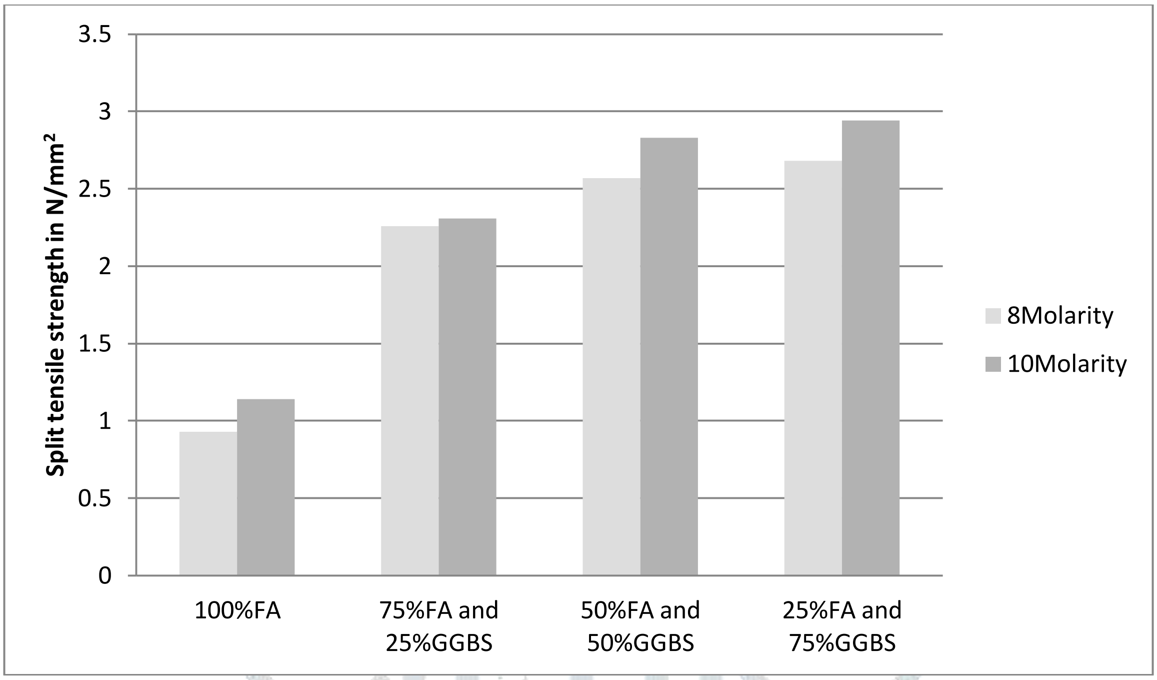

Fig 4 Split tensile strength on varying molarity for 28days

The above bar chart shows that strength of concrete increases with in concentration of sodium hydroxide.

FLEXURAL STRENGTH

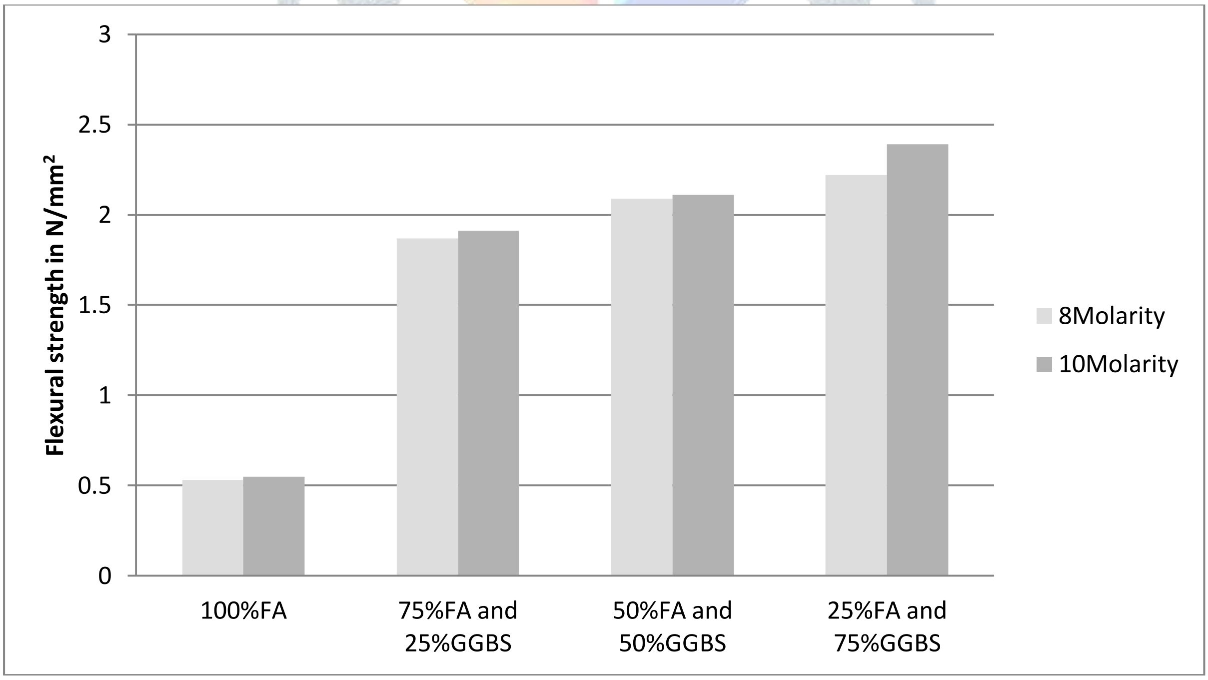

Fig 5 Flexural strength of varying molarity for 7days

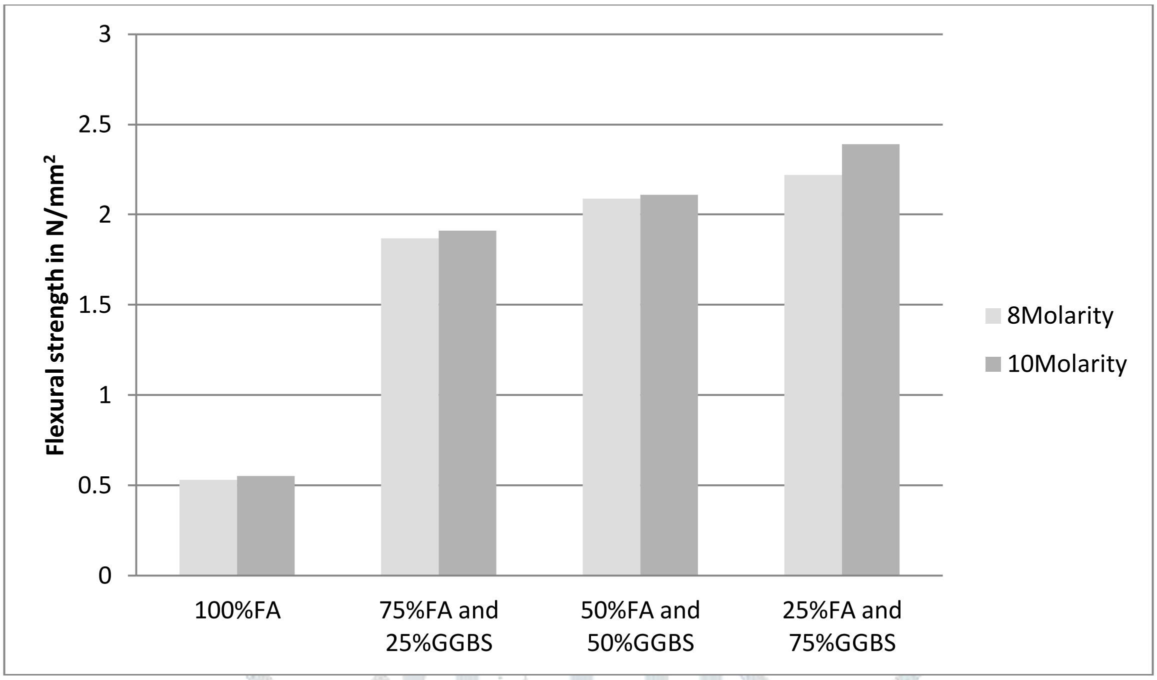

Fig 6 Flexural strength of varying for 28days

The above bar chart shows flexural strength increase with increase in molarity of sodium hydroxide.

CONCLUSION

- Increase in the percentage of GGBS, increased the strength i.e strength is directly proportional to the quantity of GGBS added.
- Increase in the molarity results in increase in strength i.e strength is directly proportional to the concentration of sodium hydroxide.
- Strength gain of concrete increases with age i.e strength increases with increase in number of days.
- Open air dry curing attained the desired strength, so practically it is more convenient.
- About 60% of the GPC strength is attained within 7days of curing period.

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