CHAPTER-1
INTRODUCTION

1.0 GENERAL

Cement concrete is a building material which consists of hard inorganic materials called aggregates such as fine aggregate (sand), and crushed rock, cemented together with Portland cement and water etc. In the last few years the construction industry is consuming very high natural resources for production of concrete due to rapid growth of industrialization. Due to the effect of this rapid utilization, the presence of natural resources will be a big question for future generations. To minimize the impact on nature, it is necessary to find alternate materials to produce concrete.

1.1 NECESSITY FOR UTILIZATION OF INDUSTRIAL BY PRODUCTS

The abandoned industrial wastes disposed in to nature have become a major environmental problem. To maintain the ecological balance, one of the possible ways is to utilize wastes and by products produced by the industries. Some of the byproducts and wastes like Fly ash, Metakaoline, rice husk ash, and Silica fume having pozzolanic properties. The main aim of environmental agencies and governments is to dispose these wastes carefully.

In this present investigation, three kinds of samples of industrial wastes and by products such as Fly ash, Metakaoline and Silica fume are employed using cold bonding pelletization process for the sustainable production of artificial light weight aggregates. The manufacturing of artificial light weight aggregates is one possible way to dispose industrial by products and wastes, and these artificial light weight aggregates acts as an alternative to the natural aggregate. It helps us to create eco friendly environment.

1.2 POZZOLANS

The pozzolanic materials can be divided in to two types, namely;

a. NATURAL POZZOLANIC MATERIALS: The following are some of the examples of natural pozzolanic materials. i.e. volcanic gases, volcanic tuffs, and calcined clays etc.
b. **BY-PRODUCT POZZOLANIC MATERIALS:** The following are some examples of by-product materials, i.e. Fly ash, iron blast furnace slag, and silica fume etc.

1.3 **PELLETIZATION OF POZZOLANIC INDUSTRIAL BY PRODUCTS**

Pelletization is a new technique that the powdered by products from the remains of industrial wastes are mixed with the binding materials like cement and lime in suitable proportions. The Pelletization process is used to manufacture light weight Coarse aggregate. In this pelletization technique, rounded balls or pellets with a mean diameter usually ranging from 5 mm to 25 mm are formed. There are different types of pelletizer machines available to make the pellets such as disc or pan type, drum type, cone type and mixer type. In this experimental investigation for preparation of pellets drum type pelletizer has been used. Initially pozzolanic material, binding materials such as cement and lime in suitable proportions are added and are mixed thoroughly in concrete mixer until the dry mix is uniform. The mix proportion in percentage, 47:47:6 i.e. pozzolanic Materials (Fly ash/Metakaoline/Silica fume): lime: cement is adopted for further work. To get this workable proportion several trials with different proportions of pozzolanic materials with binding materials were made.

While rotating the drum with this dry mix some percentage of water fixed after various trials is added and remaining water is sprinkled or sprayed in to the wet mix during the rotation period. Because while rotating the drum with moisturized mix it tends to form lumps and increase the distribution of particle size. With drum type pelletizer small grains are formed initially and are subsequently increased. The desired grain size distribution of an artificial light weight aggregate is by means of agglomeration process. In the cold bonded method increase of strength of pellets is achieved by increasing the pozzolanas / lime and cement content by weight. Some of the parameters need to be considered for the efficiency of the production of pellets are speed of revolution of pelletizer, moisture content, and angle of pelletizer and duration of Pelletization. Moisture content and angle of drum parameter influence the size and growth of pellets. The dosage of binding agent is more important for making the pellets. The pellets are formed approximately in duration of 6 to 7 minutes.
Pelletization of above materials is done by using a rotating drum with fixed blades with adjusting inclination from $12^\circ$ – $15^\circ$. For hardening of green pellets there are several methods like sintering, autoclaving and cold bonding methods etc. In this study cold bonded method is adopted for hardening of green pellets. The pellets are allowed for hardening by normal water with 28 days curing. The setup of machine for manufacture of pellets is as shown in plate 1.1

Plate 1.1 Pelletization Machine (Drum type Pelletizer)

1.4 FLY ASH AGGREGATE

Fly ash that is collected directly from the electro static precipitators of Rayalaseema Thermal Power Plant (RTPP) located at Muddanuru town of Andhrapradesh state, India has been used in the present study. An attempt has been made to make fly ash pellets with various proportions of fly ash, lime and cement mixing with 24% (by weight) of water. The mix proportion in percentage, 47:47:6 i.e. pozzolanic Material (fly ash): lime: cement is finally selected and adapted for further study. The amount of water is added to the mix proportion is purely on the basis of trial and error method till the formation of pellets, which is around 20 to 23% of total weight of materials.
1.5 METAKAOLINE AGGREGATE

The Metakaoline is procured from M/S KOAT MANUFACTURING COMPANY, Vadodara, Gujarat. Metakaoline is obtained by calcinations of pure or refined kaolinite clay at a temperature between 650°C to 850°C, followed by grinding to achieve a fineness of 700 to 900 m²/kg. The resulting material has high pozzolanic property. This is not a by-product. The Pelletization process is used to manufacture of cold bonded pelletized light weight metakaoline aggregate. In the next attempt metakaoline is used for preparation of aggregates. In the cold bonded method increase of strength of pellets is by increase the Metakaoline / lime and cement ratio by weight. In the present investigation an attempt has been made to use the metakaoline as the basic ingredient in the preparation of artificial light weight aggregate using lime and cement as binders. Here attempts have been made to make metakaoline pellets with various proportions of metakaoline, lime and cement mixing with 25% (by weight) of water. The mix proportion in percentage, 47:47:6 i.e. pozzolanic Material (metakaoline): lime: cement is finally selected adapted for further study. The amount of water added to the mix proportion is purely on the basis of trial and error method, which is around 20 to 23% of total weight of materials.

1.6 SILICAFUME AGGREGATE

The source of Silica Fume is Ferro silica unit at Kurnool. Silica Fume also known as micro silica a byproduct of the reduction of high purity quartz with coal in electrical furnaces in the production of Silicon and ferrosilicon alloys. Silica Fume is collected as a byproduct of other silicon alloys such as ferromanganese, ferromagnesiam, and calcium silicon. Before the mid 1970s, nearly all the Silica Fume was discharged into the atmosphere. After environmental concerns necessitated the collection and land filling of Silica Fume, it became economically justified to use Silica Fume in various applications. Further in this study an attempt has been made to use the Silica fume as the basic ingredient in preparation of artificial aggregate using lime and cement as binders mixing with 25% of water by weight. The mix proportion in percentage, 47:47:6 i.e. pozzolanic Material (Silica fume): lime: cement is finally selected adapted further. The amount of water is used to the mix proportion is purely
on the basis of trial and error method, which is around 20 to 23% of total weight of materials.

1.7 IMPORTANCE OF PELLETIZED COLD BONDED LIGHT WEIGHT AGGREGATES.

The main important characteristic of cold bonded pelletized light weight aggregate is its low thermal conductivity, lower density, internal curing property, and having good workability due to rounded in shape etc.

1.8 MODES OF CRACKING.

The displacement or separation of an object or material in to two or more pieces under the action of stress is called crack or fracture. If this separation or displacement is develops perpendicular to the surface of displacement, it is called as tensile crack or normally called as crack. The displacements are develops tangentially to the surface of displacement, then it is called as shear crack.

This crack will grow with time (Fig 1.1). Due to the presence of the crack the strength of the structure will decrease, which will be lower than the original design strength. The variation of residual strength of a structural element with variations in crack size and time is shown in Fig 1.2.

![Fig 1.1 Variation of crack size with load and time](image1)

![Fig 1.2 Variation of residual strength of material with crack size and time](image2)

The cracks in a structural element can be divided in three different modes, namely opening mode (Mode-I), sliding mode (Mode-II), and tearing mode (Mode-III).
Normal stresses give rise to the “Opening mode” denoted as Mode-I in which the displacements of the crack surfaces are perpendicular to the plane of the crack.

In-plane shear results in Mode-II or “Sliding mode”, in which the displacement of the crack surfaces is in the plane of the crack and perpendicular to the leading edge of the crack (crack front).

The “Tearing mode” or Mode-III is caused by out-of-plane shear in which the crack surface displacements are in the plane of the crack and parallel to the leading edge of the crack.

Mode I: Opening Mode. Mode II: In-plane shear. Mode III: Out of plane shear

Fig 1.3 Different modes of cracking

Shear and punching shear failures in deep beams in corbels and in concrete flat slabs are considered to be more critical and catastrophic than other types of failures. This area has received greater attention in recent years due to various attempts which have been made to develop Mode-II (sliding shear) test specimen geometries for investigating the shear type of failures in cementitious materials. Mode-II or edge sliding mode is associated with crack surface displacements in the crack plane and normal to the crack face. Mode II fracture is supposed to be the common type of fracture in a wide variety of civil engineering structures. It is thought to be one of the catastrophic fractures.
1.9 STRENGTH PROPERTIES

The following methods are adapted to know the mechanical strength properties as per IS code method.

1. Compressive strength (I.S.516-1959 reaffirmed as 2004),
2. Split Tensile Strength (I.S.5816-1970),
3. Flexural strength,
4. In-plane shear strength (Mode-II) etc.

1.10 DURABILITY OF CONCRETE

Durability is defined as the service life of a material under given environmental condition. Generally, water tight concrete structures endure for a long time. The durability of concrete to aggressive waters is responsible for the fact that its use has been extended to severe industrial and natural environments.

1.10.1 ACID ATTACK

Acid attack studies are carried out experimentally using different chemicals. In this present experimental investigation, 5% solutions of three acids namely; (1) Sulphuric Acid (H₂SO₄), (2) Hydrochloric Acid (Hcl) and (3) Sodium Sulphate (Na₂SO₄) for 28 days and 90 days of curing are used.

1.10.2 TEMPERATURE STUDIES

The specimens of size 150x150x150mm cubes were cast and exposed to elevated temperature and tested.

1.11 MICRO STRUCTURAL ANALYSIS

The micro structural analysis is carried out to know the compounds and minerals in the different mixes of cold bonded pelletized aggregate concrete. The samples are collected from tested specimens of different mixes.