Application Structural Lightweight Concrete

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١.INTRODUCTION

Concrete is a composite material that is ordinarily made by consolidating bond (combining cement), aggregates, water and frequently, mineral admixtures in suitable extents [١]. Concrete is likewise considered in a biphasic display, which has two stages making out of coarse totals encompassed by a mortar blend that incorporates fines, adjuvant, folios and water voids [٢].
By and by, ٦٠-٨٠٪ of cement, by volume, contains totals, which intentionally influence the properties of cement. Subsequently properties of total including shape, surface, measure, dampness content, particular gravity, any in place chemicals, are critical for the properties of cement. Besides, Concrete is the world's most generally utilized development material inferable from its phenomenal flexibility, accessibility and economy. In spite of all points of interest related with the utilization of cement in structural designing foundations, its utilization is at times constrained in a few structures as a result of its high self weight contrasted with other development materials.

A correlation of the properties of lightweight cement with ordinary cement is the most essential objective of this investigation. The most essential properties of solid, which were contrasted and each other is compressive quality, static modulus of flexibility, part rigidity and droop stream. The lower thickness and higher protecting limit are the best clear qualities of lightweight total cement by which it separates itself from conventional typical weight concrete. Light weight total and lightweight total cement are not new materials. Lightweight total cement has been known since the beginning of Roman realm. Both the colosseum and the pantheon were incompletely developed with materials that can be described as a lightweight total solid (total of squashed magma, pulverized block and pumice) [٣].

These sorts are red square total, red clay total and white thermostone total. Every one of these sorts have been brought from development squander. The principle claims to fame of lightweight cement are its low thickness and warm conductivity. Its focal points are that there is a decrease of dead load, speedier building rates in development and lower haulage and dealing with costs. The working of 'The Pantheon' of lightweight solid material is as yet standing prominently in Rome as of not long ago for around ١٨ hundreds of years as appeared in Figure ١. it demonstrates that the lighter materials

can be utilized as a part of solid development and has an efficient favorable position [٤].

FIGURE ١: ‘The Pantheon’ Rome

١.١ History and Background

Lightweight concrete has been used in development since earlier than the days of the Roman Empire. The earliest sorts of lightweight concrete were made by means of the use of Grecian and Italian Pumice as the light-weight aggregate. Ordinary hydrated burned lime was once used as the cementations cloth in the mix. These early lightweight concrete, by way of purpose of the needless to say susceptible materials, fell far short in structural overall performance of what we expect and acquire today. They were, however, amazingly durable, and existing examples of these early light-weight concrete are nevertheless to be determined in a number early buildings of Mediterranean area [٥].
two Lightweight structural concrete, also acknowledged as lightweight excessive performance concrete,
has numerous valuable characteristics such as excellent freezing and thawing durability, inside curing, and reduced dead load. The definition of excessive overall performance is subjective. It can imply high electricity or low unit weight or an aggregate of the two.

In commonplace high performance can be concept of as super lativity of one or more measureable parameters [٦].

١.٢ Definitions of Lightweight Concrete

Lightweight concrete mixes are often used in
the development enterprise the place weight savings is a necessary factor. One of the most common uses for lightweight concrete is with floor, roof or bridge decks; others consist of pavement systems, masonry blocks and offshore oil structures. Lightweight concrete is made by way
of replacing some or all of
the ordinary weight mixture with lightweight aggregate. Often the coarse fraction is replaced with lightweight mixture and the fines
are ordinary weight sand [٧]. Where Lightweight Concretes Differ? The use of lightweight concrete dates again to as early as the eighteenth century, and as advances in constructing and building technological know-how have increased, so has the use of lightweight concrete as the benefits of lighter useless load concrete have turn out to be apparent [٨].

١.٢.١Properties of Lightweight Aggregates

Color: Lightweight aggregates are normally dark gray, brown, reddish brown, rust-colored or even orange.
Polishing: Because they have a massive quantity of interior voids, the combination does now not polish well. Lightweight combination polished with a ٣٠٠٠ grit diamond pad will still continue to be dull because of the open nature of the aggregate. Air does not polish.
Strength: The compressive strength, elastic modulus, splitting tensile strengths and different homes light-weight concrete are drastically affected by way of the structural and physical residences of the light-weight mixture used. The mixture itself need to possess suited houses such as sufficient compressive strength, porosity, appearance, abrasion resistance and correct bonding with the cement paste. For this reason, non-structural light-

weight combination such as perlite, vermiculite, Styrofoam and air are now not viewed splendid for structural concrete, however instead locate uses in concrete supposed for insulation or as a light-weight filler [٩].

The most important difference between normal-weight and light-weight concrete is the use of light-weight aggregates contained inside the mix. The lightweight concrete density is less due to the fact lightweight coarse aggregates and every so often light-weight excellent aggregates are used, which make the concrete weigh less.
There are a number of types of light-weight aggregates available nowadays together with expanded shale, expanded clay, improved slate, accelerated slag, vermiculite, perlite, pumice, scoria, and fly ash. Typically, a direct relationship exists between density of the aggregate and compressive power of the concrete when all other variables are held constant. Lower density aggregates are specifically used for insulating, temporary construction, or moderate-strength concrete applications. Higher density aggregates, such as extended shales, clays, slates, slags, pumice, and scoria, which yield greater energy concrete, are used for structural lightweight concrete purposes [١٠].

Structural lightweight concrete has an in -place density (unit weight) on order of ١٤٤٠ to ١٨٤٠kg/m٣ in contrast to regular weight concrete with a density in the vary of ٢٢٤٠ to ٢٤٠٠ kg/m٣. For structural functions the concrete power should be greater than ١٧ Mpa. The concrete mixture is made with a lightweight coarse aggregate. In some instances, an element or the complete excellent combination may be a light-weight product.
The important use of structural lightweight concrete two is to reduce the dead load of concrete structure, which then lets in the structural clothier to minimize the dimension of columns, footing and other load bearing elements. Structural light-weight concrete combination can be designed to achieve similar strengths as everyday weight concrete. The equal is true for other mechanical and durability performance requirements. Structural light-weight concrete offers an extra environment friendly electricity - to- weight ratio in structure elements. In extra cases, the marginally higher cost of the light-weight concrete is offset by using dimension discount of structural elements, much less reinforcing metal and decreased volume of concrete, resulting in decrease overall cost. two [١١].

Why would you use Structural lightweight concrete? The principal purpose is to limit the ordinary load or weight of the whole concrete structure, which

then permits the structural dressmaker to minimize the dimension of columns, footings and different load bearing elements.

Structural lightweight concrete mixes can be designed to acquire similar compressive strengths as everyday weight concrete. They additionally have the identical sturdiness and mechanical traits as normal weight concrete. In most cases the higher price of the light-weight concrete is offset via a discount of structural elements, less reinforcing steel, and decreased quantity of concrete. In buildings, light-weight concrete will produce a higher fire rated structure. It additionally gives greater R-Values of wall factors for increased insulation properties. These two motives are why it is used for lightweight concrete floors, light-weight concrete roofing and lightweight concrete block [١٢].

١.٢.٢ TYPES OF LIGHTWEIGHT CONCRETE

Lightweight concrete can be prepared either by injecting air in its composition or
it can be achieved by omitting the finer sizes of the aggregate or even replacing them by a hollow, cellular or porous aggregate. Particularly, lightweight concrete can be
categorized into three groups:
i) No-fines concrete
ii) Lightweight aggregate concrete
iii) Aerated/Foamed concrete [١٣]

i) NO-FINES CONCRETE:

No-fines concrete can be defined as a lightweight concrete composed of cement and fine aggregate. Uniformly distributed voids are formed throughout its mass. The main characteristics of this type of lightweight concrete is it maintains its large voids and not forming laitance layers or cement film when placed on the wall.

The term no-fines concrete generally means concrete composed of cement and a coarse (٩-١٩mm) aggregate only (at least ٩٥ percent should pass the ٢٠mm BS sieve, not more than ١٠ percent should pass the ١٠mm BS sieve and nothing should pass the ٥mm BS sieve), and the product so formed has many uniformly distributed voids throughout its mass.

No-fines concrete is mainly used for load bearing, cast in situ external and internal wall, non load bearing wall and under floor filling for solid ground floors (CP III: ١٩٧٠, BSI). No-fines concrete was introduced into the UK in ١٩٢٣, when ٥٠ houses were built in Edinburgh, followed a few years later by ٨٠٠ in Liverpool, Manchester and London.

This description is applied to concrete which contain only a single size ١٠mm to ٢٠mm coarse aggregate (either a dense aggregate or a light weight aggregate such as sintered PFA). The density is about two-third or three quarters that of dense concrete made with the same aggregates.

No-fines concrete is almost always cast in situ mainly as load bearing and non load bearing walls including in filling walls, in framed structures, but sometimes as filling below solids ground floors and for roof screeds.

No-fines concrete is thus an agglomeration of coarse aggregate particles, each surrounded by a coating of cement paste up to about ١٠٣ mm (٠٠٠٥ in.) thick. There exist, therefore, large pores within the body of the concrete which are responsible for its low strength, but their large size means that no capillary movement of water can take place.

Although the strength of no-fines concrete is considerably lower than that of normal-weight concrete, this strength, coupled with the lower dead load of the structure, is sufficient in buildings up to about ٢٠ storey high and in many other applications.

FIGURE ٢: No-fines Concrete [٢]

No-fines concrete usually used for both load bearing and non-load bearing for external walls and partitions. The strength of no-fines concrete increases as the cement content is increased. However, it is sensitive to the water composition. Insufficient water can cause lack of cohesion between the particles and therefore, subsequent loss in strength of the concrete. Likewise, too much water can cause cement film to run off the aggregate to form laitance layers, leaving the bulk of the concrete deficient in cement and thus weakens the strength.

ii) LIGHTWEIGHT AGGREGATE CONCRETE:

Porous lightweight combination of low particular gravity is used in this lightweight concrete as an alternative of regular concrete. The lightweight aggregate can be natural mixture such as pumice, scoria and all of those of volcanic beginning and the artificial combination such as elevated blast-furnace slag, vermiculite and clinker aggregate. The foremost attribute of this light-weight combination is its high porosity which results in a low precise gravity [١٤].

The lightweight aggregate concrete can be divided into two types according to its application. One is partially compacted lightweight aggregate concrete and the other is the structural lightweight aggregate concrete. The partially compacted lightweight aggregate concrete is mainly used for two purposes that is for precast concrete blocks or panels and cast in-situ roofs and walls. The main requirement for this type of concrete is that it should have adequate strength and a low density to obtain the best thermal insulation and a low drying shrinkage to avoid cracking [٢].
Structurally lightweight aggregate concrete is fully compacted similar to that of the normal reinforced concrete of dense aggregate. It can be used with steel reinforcement as to have a good bond between the steel and the concrete. The concrete should provide adequate protection against the corrosion of the steel. The shape and the texture of the aggregate particles and the coarse nature of the fine aggregate tend to produce harsh concrete mixes. Only the denser varieties of lightweight aggregate are ٦ suitable for use in structural concrete [٢]. Figure ٣ shows the feature of lightweight aggregate concrete [١٢].

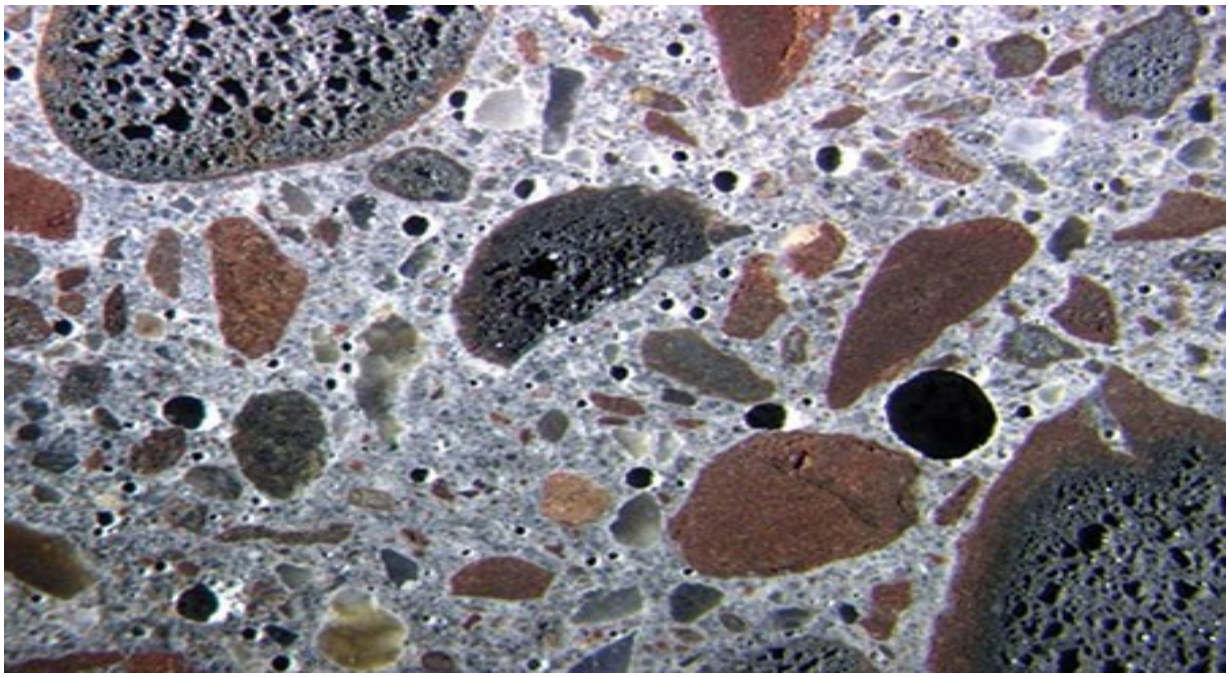


FIGURE ٣: Lightweight Aggregate Concrete [٤]

iii) AERATED CONCRETE:

Aerated concrete does not incorporate coarse aggregate, and can be considered as an
aerated mortar. Typically, aerated concrete is made with the aid of introducing air or different fuel into a cement slurry and excellent sand. In business practice, the sand is replaced with the aid of pulverizedfuel [١٤]

Concrete of this type has the lowest density, thermal conductivity and strength. Like timber it can be sawn, screwed and nailed, however there are non-combustible. For works in situ the standard strategies of aeration are by using mixing in stabilized foam or by using whipping air in with the resource of an air entraining agent. The precast products are commonly made with the aid of the addition of about ٠.٢ percentage aluminums powder to the combine which reacts with alkaline components in the binder forming hydrogen bubbles. Air-cured aerated concrete is used where little strength is required e.g. roof screeds and pipe lagging. Full electricity improvement depends upon the reaction of lime with the siliceous aggregates, and for the equal densities the electricity of high pressure steam cured concrete is about twice that of air-cured concrete, and shrinkage is solely one ٠.٣٣ or less [١٢].

FIGURE ٤: Aerated Concrete [٣]

١.٢.٣ The Importance of Water

Extra care and interest need to be paid when working with air dry lightweight aggregate, or a pre-blended light-weight concrete mix that can only have air dry substances in it (otherwise it would prematurely set due to the moisture inside the aggregate). The dry aggregate will effortlessly take in some of the mix water, requiring persevered doses of more water. It is at this point that it is extremely important that something more water is added be dosed with gorgeous care, and that all batches of concrete have identical amounts of water delivered to it. Concrete that has distinctive quantities of combine water, and consequently different water to cement ratios, will have one-of-a-kind structural, shrinkage and aesthetic characteristics. Concrete that looses mix water to thirsty aggregate during the indispensable section when the concrete is setting can showcase plastic shrinkage, surface map crazing, color variation, mottling and other undesirable and avoidable problems. Undisciplined and uncontrolled additions of unknown quantities of water will significantly affect the performance, sturdiness and look of the completed concrete two [١٥].
The above factors depend on:

a) types of aggregates used
b) the mixture
c) the density
d) the methods and techniques of preservation

٢. Application of lightweight concrete

Uses of Structural Lightweight Concrete

- Floors in steel frame buildings (lightweight concrete on fire-rated steel deck assemblies)
- Concrete frame buildings & parking structures (all types, including post-tensioned floor systems)
- Bridge decks, piers & AASHTO girders
- Specified density concrete
- Lightweight concrete precast & pre stressed elements (beams, double-tees, tilt-up walls, raised access floor panel planks, hog slats, utility vaults, pipes, ornamentals, etc.)
- Marine structures, floating docks, ships, & offshore oil platforms
- Fill concrete and insulating concrete [١٣].

The fundamental use of mild weight concrete is to decrease the useless load of the concrete structure, which then approves the structural fashion designer to minimize the measurement of the column, footing and different load bearing elements. Structural lightweight concrete mixture can be designed to obtain comparable electricity as regular weight concrete. The equal is real for the other mechanical and sturdiness performance requirements. Structural lightweight concrete offers an extra efficient strength-to-weight ratio in structural elements. Lightweight Concrete is used when structural concerns require. Lightweight Concrete is ideal for roof deck repairs, stair pan fill, expanded ground slabs or overlays on present ground decks. It can additionally be used for appliance platforms, curbs, down spout gutters, balconies, floors, fish ponds, walls, putting posts, castings, steps, or without a doubt any job that would typically be accomplished with widespread weight concrete. Use it the place ease in lifting and carrying is important. Lightweight Concrete additionally offers slower temperature transfer rates than fashionable weight concrete, resulting in extended insulation factors [٨].

Lightweight concrete can be subdivided into agencies such as ultra-lightweight and structural lightweight, relying on the density of the aggregate. Concrete with aggregate density less than ٥٠٠ kilograms per cubic meter (٣١ pounds per cubic foot), for example, is regarded ultra-lightweight, while structural concrete typically falls in the range of ١,١٠٠ to ١,٧٥٠ kilograms per cubic meter (٧٠ to one hundred ten kilos per cubic foot). Most structural, masonry and insulating concretes are lightweight. Heavyweight concrete, by way of contrast, is most regularly used for radiation shielding, even though it also is used in the development of ballasts for offshore pipelines [١٦].

٢.١ Global application

٢.١.١ Wellington Regional Stadium

Wellington Regional Stadium (known as Westpac Stadium through naming rights) is a major sporting venue in Wellington, New Zealand. The stadium's bowl site size is ٤٨,٠٠٠ sq m. The huge stadium was built in ١٩٩٩ by Fletcher Construction The stadium was built in ١٩٩٩ by Fletcher Construction[٣] and is situated close to major transport facilities (such as Wellington Railway Station) one kilometer north of the CBD. It was built on reclaimed railway land, which was surplus to requirements [١٧].

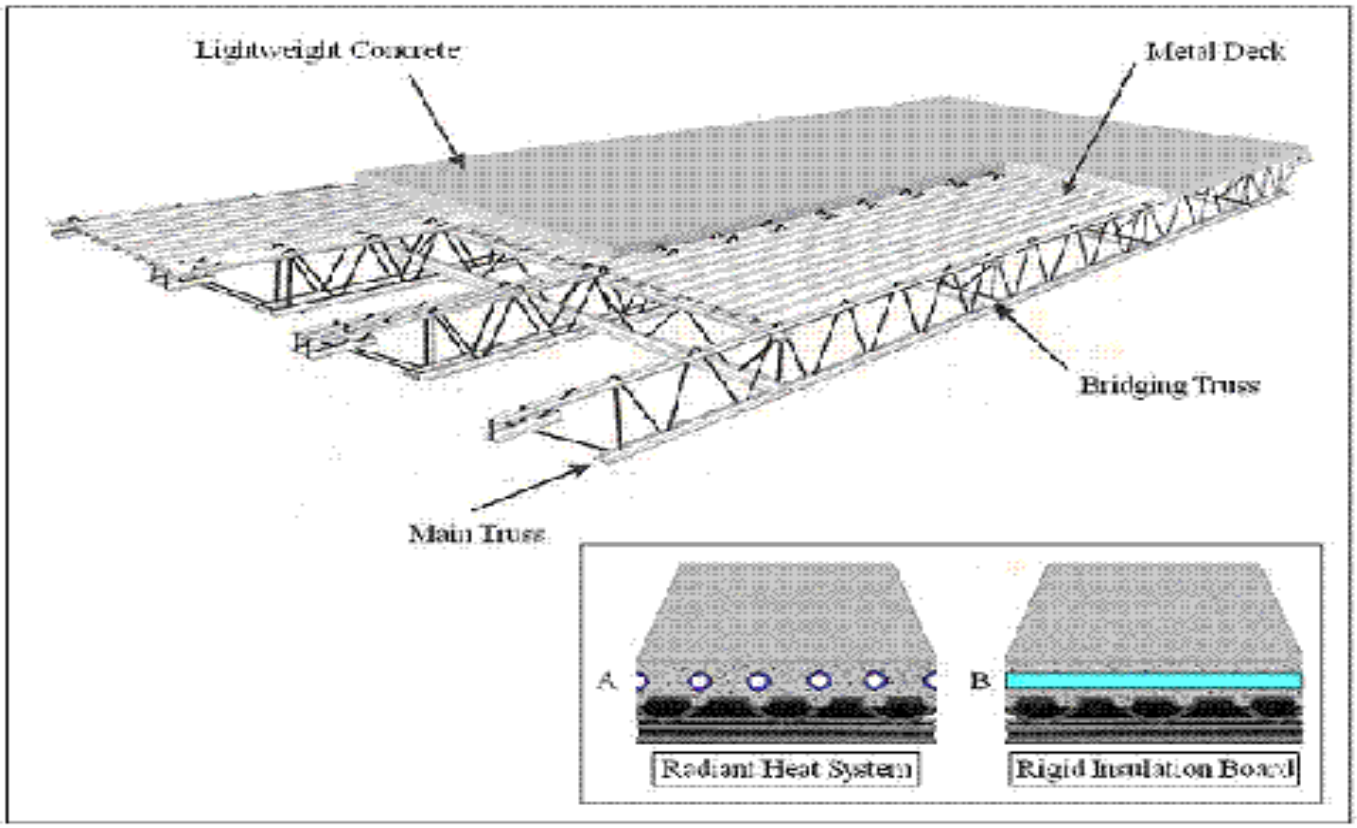
٢.١.٢. The Raftsund Bridge

The Raftsund Bridge in USA was Beginning of works in ١٩٩٧ and opened on November ٦, ١٩٩٨, It was the last of the long bridges connecting the Vesterålen islands. The bridge is ٧١١ meters long, the main span is ٢٩٨ meters, and the maximum clearance to the sea is ٤٥ meters. The bridge has ٤ spans.

٢.١.٣. The Duke Energy Center

The Duke Energy Center is a (٢٤٠ m) tall, ٤٨-floor (٥٤ floors including mechanical floors) skyscraper in Charlotte, North Carolina. The project was announced in spring of ٢٠٠٤, The building received a certificate of occupancy December ٢٣, ٢٠٠٩, with the lobby and parking garage opening January ٢, ٢٠١٠, it was the largest building in Charlotte (in square footage), second tallest building in Charlotte, ٦٣rd tallest building in the United States.

٢.٢.٤. Application for insulated properties



Application for insulated properties as well as a sound barrier for lightweight composite roof or floor deck in commercial, industrial, residential buildings/structures. This would especially true for power utility problems currently being experienced in hot and cold regions where electricity, gas or oil consumption is an issue. Heating and cooling costs are reduced.

Architects have been specifying lightweight concrete steel decking for years. Cost has always been an issue from rising and falling prices associated with lightweight aggregates, this is especially true with expanded shale, clay and slate. The cost to produce these in the immediate future will rise significantly.

A radiant PCMs/HPCC [Phase Change Materials/ High-Performance Cellular Concrete] floor would be an excellent choice for a high energy efficient abatement system [١٨].

٢.١.٥. George P. Coleman Memorial Bridge

Originally built in ١٩٥٢, it was reconstructed and widened in ١٩٩٥ through an unusual process which greatly reduced the time the important commuter artery was out-of-service from conventional methods. The current ٣,٧٥٠-foot (١,١٤٠ m)-long double-swing-span bridge carries United States Route ١٧, a four-lane arterial highway. The movable span is needed to allow ship access to several military installations that are upstream of the bridge, most notably, the United States Navy's Naval Weapons Station Yorktown. The roadways are almost ٩٠ feet (٢٧ m) above the river at the highest point of the bridge. The bridge is the largest double-swing-span bridge in the United States, and second largest in the world.

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