

# **LIGHT WEIGHT CONCRETE**

**PREPARED BY CIVIL ENGINEER :-**

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**Introduction:**

Lightweight concrete has extreme importance to the construction industry. Most of current concrete research focuses on high-performance concrete, by which is meant a cost-effective material that satisfies demanding performance requirements, including durability. Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as lessened the dead weight. It is lighter than the conventional concrete. The use of lightweight concrete has been widely spread across countries such as USA, United Kingdom and Sweden.

The other main specialties of lightweight concrete are its low density and thermal conductivity. So its advantages are that there is a reduction of dead load, faster building rates in construction and lower transport and handling costs.

Lightweight concrete maintains its large voids and not forming laitance layers or cement films when placed on the wall. Sufficient water cement ratio is vital to produce adequate cohesion between cement and water. Insufficient water can cause lack of cohesion between particles, thus loss in strength of concrete. Likewise too much water can cause cement to run off aggregates to form laitance layers, subsequently weakens in

## **What is the light weight concrete?**

Light weight concrete (foamed concrete) is a versatile material which consists primarily of a cement based mortar mixed with at least 20% of volume air. The material is now being used in an ever increasing number of applications, ranging from one step house casting to low density void fills.

Light weight concrete has a surprisingly long history and was first patented in 1923, mainly for use as an insulation material. Although there is evidence that the Romans used air entertainers to decrease density, this was not really a true Light weight concrete. Significant improvements over the past 20 years in production equipment and better quality surfactants (foaming agents) has enabled the use of foamed concrete on a larger scale.

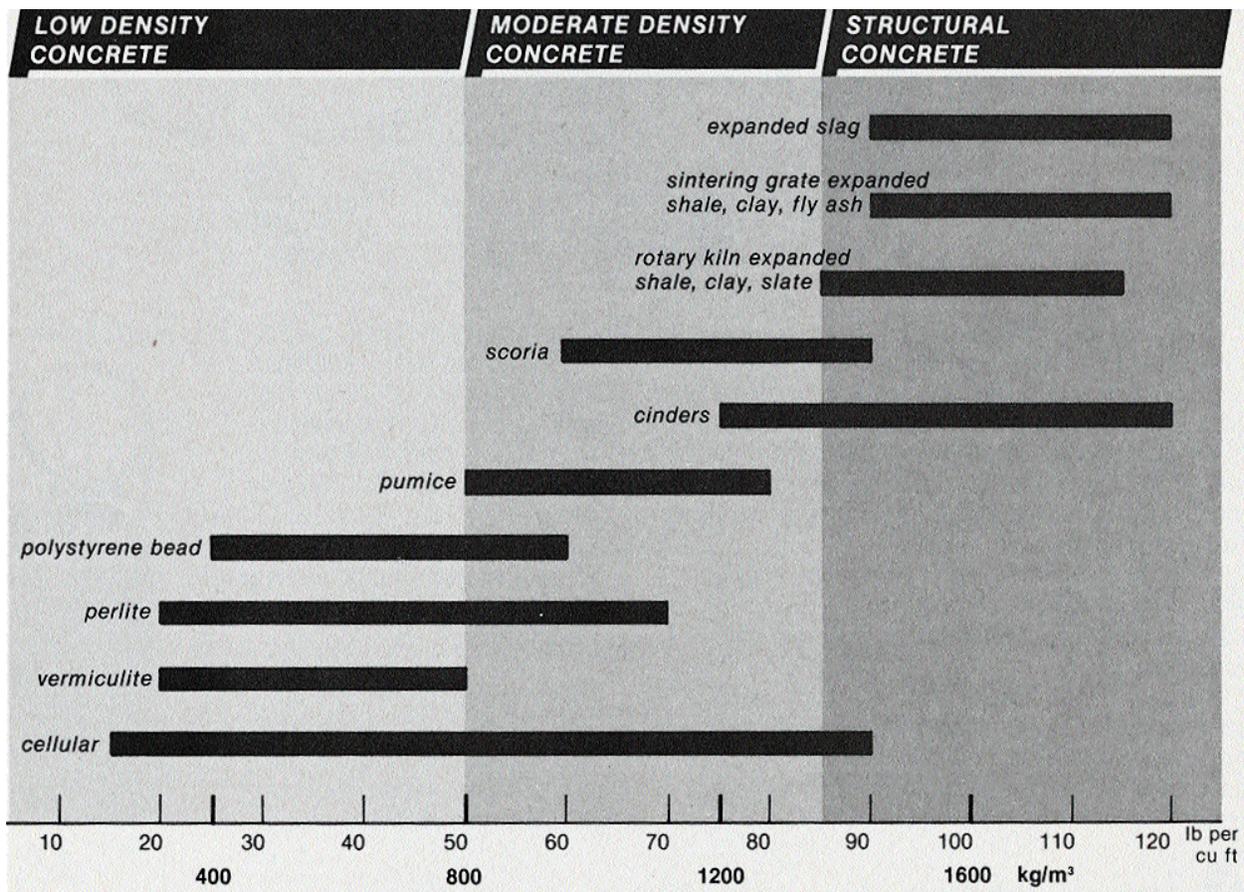
Lightweight and free flowing, it is a material suitable for a wide range of purposes such as, but not limited to panels and block production, floor and roof screeds, wall casting, complete house casting, sound barrier walls, floating homes, void infill, slope protection, outdoor furniture and many more applications.

Not everyone knows that density and compressive strength can be controlled. In the light weight concrete this is done by introducing air through the proprietary foam process which enables one to control density and strength precisely.

Normal concrete has a density of 2,400 kg/m<sup>3</sup> while densities range from 1,800, 1,700, 1,600 down to 300 kg/m<sup>3</sup>. Compressive strengths range from up to 40 MPa down to almost zero for the really low densities. Generally it has more than excellent thermal and sound insulating properties, a good fire rating, is non-combustible and features cost savings through construction speed and ease of handling.

The technology is the result of over 20 years of R&D, fine tuning the product and researching the possible applications. It is used in over 40 countries worldwide today and has not reached the end of its possible uses. Lightweight concrete is concrete weighing substantially less than that made using gravel or crushed stone aggregates. This loose definition is generally agreed to cover a broad spectrum of concretes ranging in weight from 12 to 120 pounds per cubic foot. Many types of concrete fall within this range; some are cellular concretes made with foam or foaming agents; some are made with lightweight aggregates; and some cellular concretes also contain

lightweight aggregates. Other lightweight concretes may contain some normal weight sand. The compressive strength of these concretes covers an even broader spectrum, with structural lightweights at 6000 psi and higher at one extreme, and cellular fill concretes at 5 psi at the other extreme. Lightweight aggregate concrete is usually chosen for structural purposes where its use will lead to a lower overall cost of structure than would be expected with normal weight concrete. The generally higher unit cost of lightweight structural concrete is offset by reduced dead loads and lower foundation costs. There may be a special advantage when existing structures are being altered or expanded. For example, four stories were added to an existing Cleveland department store without modifying the foundation. When the Tacoma Narrows Bridge was replaced, the original piers were able to carry the load of additional traffic lanes, thanks to the use of structural lightweight concrete in the bridge deck.



### Compressive strength

Lightweight aggregate particle strength varies with type and source of aggregate, and there is no reliable correlation between aggregate strength and concrete strength. All aggregates have strength ceilings, that is, a maximum strength attainable with a reasonable quantity of cement. The compressive strength of lightweight aggregate concrete is usually related to the cement content at a given slump, rather than to the water/cement ratio. The table shows some approximate relationships between average strength and cement content. In some cases, compressive strength can be increased by replacing part of the fine lightweight aggregate with good quality natural sand.

APPROXIMATE RELATIONSHIP BETWEEN CEMENT	
Compressiv strength,	Cement content, pounds per cubic <i>All lightweight Sanded</i>
2500	400 - 510 400 -
3000	440 - 560 420 -
4000	530 - 660 490 -
5000	630 - 750 600 -
6000	740 - 840 700 -
Based on data from ACI	

### Types of aggregates

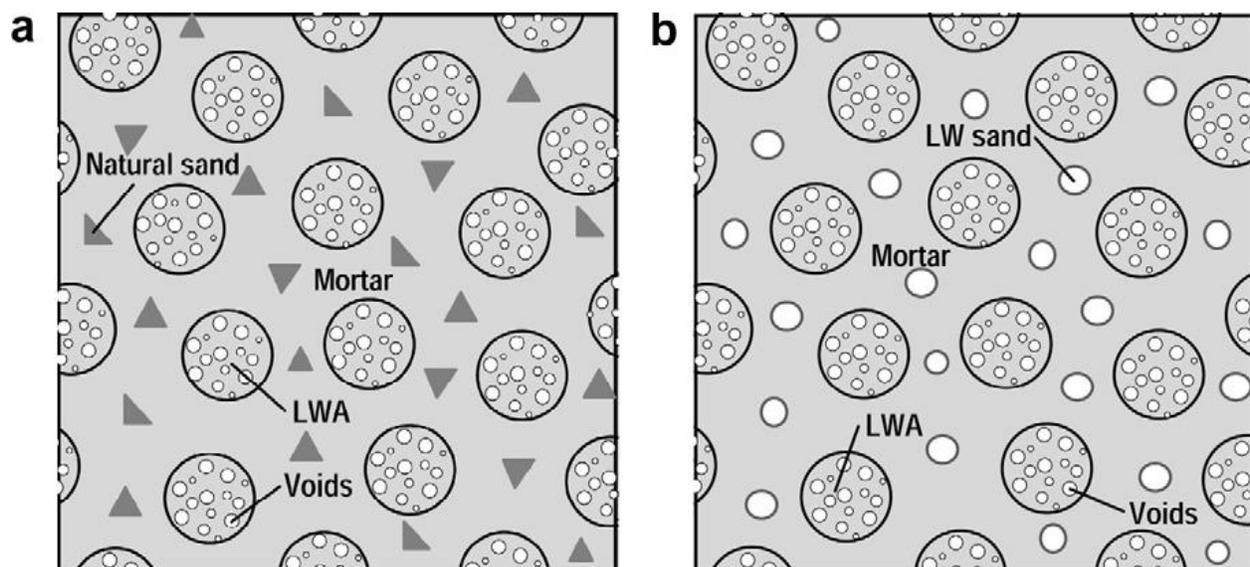
According to ACI (the American Concrete Institute), structural lightweight aggregate concretes have a 28-day compressive strength of 2500 psi<sup>4</sup> or more and a weight not exceeding 115 pounds per cubic foot. Lightweight concrete may also contain normal or lightweight, fine and/or coarse aggregates. The rigid foam air cell system differs from conventional aggregate concrete in

the methods of production and in the more extensive range of end uses. Lightweight concretes for structural use derive their special properties from the use of low density aggregates whose particles have an internal cellular structure. These may be either processed or naturally occurring and unprocessed materials. The ACI guidelines for structural lightweight concrete are based on concretes made with processed aggregates meeting the requirements of ASTM Standard C 330. These include:

- Rotary kiln expanded clays, shales, and slates
- sintering grate expanded shales and clays
- Pelletized or extruded fly ash
- expanded slags

However, lightweight structural concrete may also be made with other types of aggregates such as naturally occurring pumice and scoria and with suitable cinders.

Properties of the lightweight aggregates such as particle shape and surface texture, specific gravity, unit weight, particle size, strength, moisture content, and absorption all affect properties of fresh and hardened lightweight concrete, just as comparable properties of normal weight aggregates do, but the quality of the cement paste also has an important influence on properties of the concrete.



Schematic graphs of concrete with only coarse LWA (a) and concrete with both coarse and fine LWA (b).

### **Mix design of the light weight concrete**

Concrete mix design is the process of choosing suitable ingredients of concrete and determining their relative quantities with the objective of producing the most economical concrete while retaining the specified minimum properties such as strength, durability, and consistency (Akhras and Foo, 1994; Neville, 1995).

The selection of ingredient is normally done using data from tables and charts in the relevant mix design standard. While these data and numerical examples in the codes are sufficient to guide the mix designer, it is thought worthwhile to add more values to these data for convenience of the users.

Researchers have supported the need to present mix design data in form of graphs or equations. Most people involved in mix design of concrete may be more comfortable using equations to calculate the ingredient of concrete. The calculation of batch compositions using the mix design codes only give the first starting point (Neville, 1995; ACI 211.2- 98; ACI 211.1-91; ACI 213-87). This is because the codes were developed from experience with certain materials in some parts of the world which may not be applicable for some materials in other parts of the world. The determination of accurate mix ingredient of concrete becomes more difficult when lightweight aggregates are used because of the problem associated with it such as high water absorption, lightweight, porous nature and surface texture. For this type of concrete it is obvious that searching for the optimum mix ingredients is quite a difficult task. Optimum compositions may be attained by testing of concrete, re-calculations and mix adjustment as deem necessary. This process can be made less bulky if the relevant equations are used for mixture proportioning.

### **Mixing and placing**

In general, procedures for mixing lightweight structural concrete are similar to those for regular weight concretes, but some of the more absorptive aggregates may require prewetting prior to addition of other mix ingredients.

Water added at the batching plant should be sufficient to provide the specified slump at the building site; slump at the batching plant will probably be appreciably higher. Adequate workability, as indicated by the concrete slump, is necessary in order to realize all of the desired properties of the hardened concrete. Slump for floor concretes is generally limited to 4 inches, but a lower slump of 3 inches, 1 and 2 may be better for maintaining cohesiveness of the mix and preventing lighter coarse particles from working up through the mortar to the surface during finishing. With certain aggregates deficient in minus No. 301 3 sieve material, finish ability can be improved by using a portion of natural sand to supplement the lightweight fines. A well-proportioned lightweight mix can generally be placed, screeded and floated with less effort than that required for normal weight concrete. Surface preparation prior to troweling is best done with aluminum or magnesium screeds and floats to minimize surface tearing and pullouts of aggregate. Vibrating screeds may be advantageous, but over vibration and over working may cause finishing problems. Too much finishing effort can drive the heavier mortar away from the surface where it is needed and bring an excess of the lighter course aggregate to the surface.

### **Specifications**

Many structural lightweight aggregate suppliers have suggested specifications and mix proportioning information pertaining to their materials, and some offer field control and technical service to ensure that the specified quality of concrete will be used. Usual specifications for structural lightweight call for a minimum compressive strength, maximum slump, maximum weight, and both maximum and minimum values for air content. However, the contractor will also be concerned with properties of the freshly mixed concrete, such as bleeding, workability, and finish ability.

### **Fire endurance and thermal properties**

In addition to advantages based on their lightness, structural lightweight concretes resist fire better than ordinary concretes because of their lower thermal conductivity, lower coefficient of thermal expansion, and the inherent fire stability of aggregates already burned to over 2000 degrees F. For concretes exposed to the elements, structural lightweight has some advantages over normal weight concrete. The lower conductivity lengthens the time required for exposed

members to reach a steady state temperature, and this resistance reduces interior temperature changes under transient conditions. Such a time lag moderates solar buildup and nightly cooling effects. In tall buildings, the lower coefficient of thermal expansion for exposed lightweight columns means a reduction in volume changes and the stresses associated with them.

### **Advantages and disadvantages of using lightweight concrete**

#### **Advantages**

- Rapid and relatively simple construction
- Economical in terms of transportation as well as reduction in manpower
- Significant reduction of overall weight results in saving structural frames, footing or piles
- Most of lightweight concrete have better nailing and sawing properties than heavier and stronger conventional concrete



#### **Disadvantages**

- in the mixtures very sensitive with water content
- Difficult to place and finish because of the porosity and angularity of the aggregate. In some mixes the cement mortar may separate the aggregate and float towards the surface.

- Mixing time is longer than conventional concrete to assure proper mixing.

### **Application of lightweight concrete**

The primary use of light weight concrete is to reduce the dead load of the concrete structure, which then allows the structural designer to reduce the size of the column, footing and other load bearing elements. Structural lightweight concrete mixture can be designed to achieve similar strength as normal weight concrete. The same is true for the other mechanical and durability performance requirements. Structural lightweight concrete provides a more 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, elevated floor slabs or overlays on existing floor decks. It can also be used for appliance platforms, curbs, down spout gutters, balconies, floors, fish ponds, walls, setting posts, castings, steps, or virtually any job that would normally be done with standard weight concrete. Use it where ease in lifting and carrying is important. Lightweight Concrete also offers slower temperature transfer rates than standard weight concrete, resulting in improved insulation factors.

Nowadays with the advancement of technology, lightweight concrete expands its uses, for example, in the form of perlite with its outstanding insulating characteristics. It is widely used as loose-fill insulation in masonry construction where it enhances fire ratings, reduces noise transmission, does not rot and termite resistant. It is also used for vessels, roof decks and other applications.

The use of high strength, high performance lightweight concrete (HSLWC) can result in longer span lengths and lighter weight girders. Previous research at the Georgia Institute of Technology (Georgia Tech) showed that HSLWC bridge girders can be constructed with 10,000 psi (69 MPa) compressive strength concrete with a very low permeability, while achieving up to a 20% decrease in shipping weight.



A Lightweight building

## **Conclusion**

Lightweight aggregate concrete has been shown by test and by performance to behave structurally in much the same manner as normal weight concrete. For properties which differ, the differences are largely those of degree. The designer must consider the benefits of lighter weight and better insulation in relation to the extra cost of the lightweight mix. The builder must recognize the few different requirements relative to transporting, placing, and finishing. Much helpful information is available from producers of lightweight aggregates through their field control and technical service.

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