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Light Weight Concrete

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***Abstract*: This paper presents an overview on light weight concrete.**

***Keywords*: light weight concrete**

1. Introduction

One of the disadvantages of conventional concrete is the high self-weight of concrete. Density of the normal concrete is in the order of 2200 to 2600 kg/m³. This heavy self-weight will make it to some extent an uneconomical structural material. To reduce the self-weight of concrete to increase its efficiency as structural member, attempts have been made in the past. A concrete whose density varies from 300 to 1850 kg/m³ is called as light-weight concrete.

A. *Advantages of light- weight concrete*

1. It helps in reduction of dead load.
2. Increases the progress of building.
3. Lowers haulage and handling costs.
4. Reduces weight of building on foundation-in the case of weak soil and tall structures the weight of the building on foundation is an important function in design. If the floors and walls are made up of light weight concrete it will result in considerable economy.
5. Having low thermal conductivity which will be of considerable advantage from the point of view of thermal comforts and power consumption in extreme climatic condition.
6. Gives an outlet for industrial wastes like clinker, fly ash, etc.

B. *Methods of making light weight concrete*

1. By replacing the usual mineral aggregate by cellular porous or light weight aggregate.
2. By introducing gas or air bubbles in mortar. This is known as aerated concrete.
3. By omitting sand fraction from the aggregate. This is called no fines concrete.

There are mainly three main groups of light weight concrete, no fines concrete, light weight aggregate concrete, and aerated concrete. The detail of groups is given in table 1. Out of these groups, the light weight aggregate concrete and aerated concrete are more often used than the no fines concrete. Light weight concrete can also be classified on the purpose for which it is used, such as structural light weight concrete, non-load bearing concrete and insulating concrete. The aerated concrete which was mainly used for insulating purposes is now being used for structural purposes in conjunction with steel reinforcement.

C. *Light weight aggregates*

Light weight aggregates can be classified into two categories namely natural light weight and artificial light weight concrete.

Natural light weight aggregate	Artificial light weight aggregate
Pumice	Artificial cinders
Diatomite	Coke breeze
Scoria	Foamed slag
Volcanic cinders	Bloated clay
Sawdust	Expanded shales
Rice husk	Sintered fly ash
	Exfoliated vermiculite
	Expanded perlite thermocole beads.

Table 1
Groups of light weight concrete

No fines concrete	Light weight aggregate concrete	Aerated concrete	
		Chemical aerating	Foaming mixture
Gravel	Clinker	Aluminum powder method	Preformed foam
Crushed stone	Foamed slag	Hydrogen peroxide and bleaching powder method	
Coarse clinker	Expanded clay		Air-entrained foam.
Sintered pulverized fuel ash	Expanded shale		
Expanded clay	Expanded slate		
Expanded slate	Sintered pulverized fuel ash		
	Exfoliated vermiculite		
Foamed slag	Expanded perlite		
	Pumice		
	Organic aggregate		

2. Light weight aggregate concrete

Very often light concrete is made by the use of light weight aggregates. Different light weight aggregates have different densities. Naturally when these aggregates are used, concrete of different densities are obtained. Table 2, gives the typical properties of light weight aggregate concrete.

Strength of light weight concrete depends on the density of concrete. Less porous aggregate which is heavier in weight produces stronger concrete particularly with higher the cement content. The grading of aggregate, the water/cement ratio, the degree of compaction also affects the strength of concrete.

Most of the light weight aggregate with the exception of bloated clay and sintered fly ash are angular in shape and rough in texture. They produce a harsh mix. Particular care should be taken to improve workability with the addition of excess of fine materials, pozzolanic material or some other plasticizer admixtures.

Use of air-entrainment will greatly improve the workability, and the tendency of bleeding. But the use of air-entrainment will result in further reduction in strength also. Most of the light weight aggregates have a high and rapid absorption quality. This is one of the important difficulties in applying the normal mix design procedure to the light-weight concrete. Coating of aggregate by silicon compounds does not impair the bond characteristics unlike the bitumen but at the same time makes it non-absorbent.

Light-weight concrete being comparatively porous, when used for reinforced concrete, reinforcement may become prone to corrosion. Either the reinforcement must be coated with anticorrosive compound or the concrete must be plastered at the surface by normal mortar to inhibit the penetration of moisture and air inside.

3. Structural light weight concrete

The structural light weight concrete is going to be one of the important materials of the construction. It is more economical than the conventional concrete as it is light in weight and strong to be used in conjunction with steel reinforcement.

Structural light-weight concrete is the concrete having 28-day compressive strength more than 17 MPa and 28-day air dried unit weight not exceeding 1850 kg/m. the concrete may consist entirely of light-weight aggregates or combination of light-weight and aggregates and normal-weight aggregates. For practical reasons, it is common practice to use normal sand as fine aggregate and light-weight coarse aggregate of maximum size 19 mm.

Light-weight concrete exhibits higher moisture movement than the normal-weight concrete. Concrete while wetting swells more and the concrete while drying shrinks more. Due to high drying shrinkage and lower tensile strength it shows shrinkage cracks. But higher extensibility and lower modulus of elasticity help to reduce the tensile cracks.

A. Design of light-weight aggregate mix

Mix design methods applying to normal weight concrete are generally difficult to use with light weight aggregate concrete. The lack of accurate value of absorption, specific gravity, and the free moisture content in the aggregate make it difficult to apply the water/cement ratio accurately for mix proportioning.

Light-weight concrete mix design is usually established by trial mixes.

B. Aerated concrete

Aerated concrete is made by introducing air or gas into a slurry composed of Portland cement or lime and finely crushed siliceous filler so that when the mix sets and hardens, a uniform cellular structure is formed.

A common product of aerated concrete is Siporex in India.

There are several ways in which it can be manufactured:

1) By the formation of gas by chemical reaction within the mass during liquid or plastic state.
2) By mixing preformed stable foam with the slurry.
3) By using finely powdered metal with the slurry and made to react with the calcium hydroxide to give out large quantity of hydrogen gas which when contained in the slurry mix, gives the cellular structure.

Aerated concrete with low density is used for insulation purposes, medium grades are used for the manufacture of building blocks and higher grades are used in the manufacture of prefabricated structural members.

C. No-Fines Concrete

No-fine concrete is a kind of concrete from which the fine aggregate fraction has been omitted. This concrete is made up of only coarse aggregate, cement and water.

No-fines concrete is becoming popular because of some of its advantages like light in weight and it offers architecturally attractive look.

No-fines concrete is generally made with the aggregate/cement ratio from 6:1 to 10:1. Aggregates used are normally of size passing through 20 mm and retained on 10 mm. the strength of no-fines concrete, is dependent on the water/cement ratio. Aggregate cement ratio and unit weight of concrete.

Drying shrinkage of no-fines concrete is considerably lower than that of conventional concrete. It is used in large scale for load bearing cast in situ external walls for single storey and multistoried buildings. It has been used for temporary structures because of low initial cost and also for the ease with which it can be broken and reused as aggregate.

Use of lightweight concrete as a roof decking and insulation system has expanded in the past five years. Increased usage can be attributed to the recent industry-wide insulation shortages and delamination deficiencies. The increase can also be attributed to the economic and environmental advantages that lightweight insulating concrete (LWIC) provides in roof assemblies.

There are several benefits for the use of lightweight concrete on current roof applications. When provided with insulation, a thermal R-value of R-30 can be easily achieved without insulation delamination, warping or attachment concerns. An example can be seen in Miami where lightweight concrete is used on the Miami postal facility, not only provides a sound substrate for membrane application, but it can be formed to achieve proper slope without adding tapered insulation.

In addition, lightweight concrete provides the building owner with long-term cost savings. Since the lightweight construction becomes part of the structure, replacement is not required during remedial roofing applications, as is the case with insulation. Rather, only the membrane removal is required. This frees space in landfills and substantially reduces removal costs, which can be as high as 50 percent of the total project costs.

D. Disadvantages

Lightweight concrete applications do have limitations and associated liabilities. The system is installed on site and a successful application depends on the skill of the installing contractor. Lightweight concrete has additional constraints because the success of the system is based on the proper mix ratio. An improper mix can create voids in the concrete that lead to deficiencies.

One of the major disadvantages of lightweight concrete has been the inability to provide consistent compressive strengths and density throughout the entire area.

4. Case study

Use of light weight concrete on the bridge deck: Benefits;

- Reduced dead load of structure.
- Reduced handling and transportation costs for precast components.
- Enhanced durability.
- Resistance to chloride intrusion.

A. San Francisco Oakland bay bridge

Deck constructed with light-weight concrete in 1936, still in service today. No spalling was found in cores of light weight upper deck unlike the cores of normal weight upper deck where spalling was found.

B. Sebastian inlet bridge, FL

After more than 30 years wear of the light-weight concrete deck was essentially the same if slightly not less than the adjacent normal weight decks.

Fig. 1. Sebastian inlet bridge, FL

C. Suwannee river bridge, FL

- Indicates no increase in flexibility over time.
- Structural light-weight aggregate concrete used in the deck and girders have met expectations and performed satisfactory. Still in service after 41 years.

Fig. 2. Suwannee river bridge, FL

Table 2
Typical properties of light weight concrete

Type of concrete		Bulk density of aggregate kg/m³	Mix proportion by volume Cement: aggregate	Dry density of concrete kg/m³	Compressive strengths MPa	Drying shrinkage	Thermal conductivity Jm/m²s°C
Foamed slag	Fine	900	1:8	1700	7	400	0.45
			1:6	1850	21	500	0.69
Rotary kiln expanded clay	Fine	100	1:11	650-1000	3-4	-	0.17
			1:6	1100	14	550	0.31
Rotary kiln expanded slate	Fine	950					
			1:6	1700	28	400	0.61
			1:1.45	1750	35	450	0.69
Sintered Pulverized Fuel ash	Fine	1050	1:6	1450	28	400	0.47
			1:4.5	1500	36	500	0.49
			1:35	1550	41	600	0.50
Pumice		500-800	1:6	1200	14	1200	-
			1:4	1250	19	1000	0.14
			1:2	1450	29	-	-
Exfoliated Vermiculite		65-130	1:6	300-500	2	3000	0.10
Perlite		95-130	1:6	-	-	2000	0.05

5. Conclusion

The use of light-weight concrete over conventional concrete has proved advantageous. As it reduces the dead load of each member, it reduces the building load on the foundation which in turn proves economical as compared to conventional concrete. By using light-weight concrete the strength and stability of structures also improve. Hence after looking at all its advantages it has become more popular these days.

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