Lightweight structure could become advancement construction essay

City UNIVERSITYULTRA LIGHT-WEIGHT BUILDINGHow lightweight structure could become advancement in material science or through using changes in design

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Introduction

This report will illustrate some methods of constructing an ultra-lightweight building. Then by describing each type of the methods which have been discovered by my research from reliable sources such as books, journals and civil engineering sites and companies. The main aim of this project is to design new types of construction, to create a method which is reducing the dead load of a building and also be less heavy than nowadays methods. First of all, the most important fact is, why engineering is looking to reduce the weight and what are the aspects they are looking for by decreasing the weight of the structure. Now days, population are growing and so the requirement of housing and offices are increasing. These facts lead the construction companies to build taller building. On the other hand, the demands for the material needed to construct buildings are increasing too. In these days, engineering aims to make buildings which are lighter. In the same way, the stability, strength and stiffness of the structure do not reduce or reduce proportional to the amount reduction. By reducing the weight of structure, time consumption will decrease and energy spend to construct a new construction will be decrease directly and indirectly. Extra works will be eliminated by making structures lighter. Steel Frames [13] [14]One of the common methods of construction is to use steel. Engineers made the steel

frames which contain the steel hallow section columns and beams. There are two types of connection between columns and beams bolt (which use for taller building or connection between beams and columns) or welded (which use for small height buildings). On this method, slab made from concrete with minimum size of bars can be used (Beams required). The lightest way in steel frame construction is to utilize slim floor system for slabs. Slim floor system is the new method of construction which is becoming more popular these days, especially in Europe (shown in figure1). It is the combination of steel slab and concrete and matrices of bars which leads the reduction in thickness of slabs in in building. Normally sizes of slabs are between 280 to 320 mm (R M LAWSON 1992). In this method, form working on each floor does not require because steel deck is the permanent form work of the concrete. As a result, each floor has its work and does not depend to the others. These facts leads to reduce the total cost and time because casting concrete can be done in many floors in the same time. Example of steel fameFigure1. Example of slim floor construction methodAdvantages of Steel Frame Construction: [13]Steel frames are generally lighter and stronger than concrete, therefore tallest and widest buildings in the world are made from steel. Another advance point which steel has is that the steel is designed and prefabricated in factories then will be delivering to the site. In this method, assembling and production is easy. In the same way, it required reasonable cost and low-skilled labour with high quality. As a matter of design, this type of frame is quite flexible. This means large span distances and curves can be taken. In the same way, the safety and durability of steel is quite good (steel does not ignite, burn or rust). Disadvantages of Steel Frame Construction: [13]On the other hand, steel is pretty expensive compared to other materials

such as concrete or any other common material. Steel also needs fire protection layers because it is sensitive to heat (additional cost). In general, steel frames are unstable and it takes time to level them, however it is more expectable and an accurate method. Concrete Frames [1]Second method is concrete, instead of using steel frame which is expensive and it is more common. Engineers use concrete and bars on both columns and slabs. In this method the distance between the columns could not be very large in most cases. Sometimes, in order to reduce the total weight of concrete in the specific area, engineers using Polystyrene between matrices. Example of using Polystyrene and concreteThere are a few ways to decrease the weight of concrete.

Fibre Reinforce Concrete

In this method, concrete combines with short discrete fibres. The fibres are distributed uniformly. The sizes of fibres are usually about 3-20mm and randomly oriented. There are few types of materials which can be used as fibres in FRC (Steel fibres, Glass fibres, Synthetic fibres or natural fibres). In general, concrete has very high compression strength and the tensile strength of the concrete is considerably low. In order to cover the problem, engineers are adding matrices of bars. The concept of FRC is to combine concrete with one of the following fibres which has been mentioned before. Another important fact is FRC increase the impact force enormously. Some buildings using Polystyrene inside concrete to reduce sound and heat which is transfer to each floor, but fibres are an insulator to heat and sound. Advantages of this type of construction are that there is minimizing in the dead load, damages occurred by erosion or cavitation. The idea behind the

FRC is to lessen weight with same strength. Reduction in weight or dead load in structure is the one of important facts. On the other hand, the numbers of people survive from natural disaster is going down by cutting the dead load (R. Brown-2002). In the first few days after casting concrete, concrete has low strength and the possibility of shrinkage in concrete is high. In contrast, by adding polypropylene fibre which has high tensile strength, it will be strong. Ceramic Microsphere(B. Arisoy 2008)Microspheres are a lightweight, hollow sphere comprised largely of silica and alumina and filled with air. They also called Cenospheres and as well as they are manufactured they may be naturally occurring by-product of the burning process at coal-fired power plantsAir Entraining Agents(B. Arisoy 2008)Air entraining agents are air bubbles produced by chemical reactions using soap based chemicals. Cobiax Method [1] [11]The cobiax method is same as concrete method but the only difference is the dead load decrease by the Cobiax balls (made from recycled polyethylene and it fills by air). It means that the unnecessary area which was filled by concrete is now filled by balls and inside the balls are air. By this method the thickness of slabs will be minimized significantly (not in all cases). The structures have slim slab and wide span. In the same way, by reducing cost and materials engineers can reach their goals much easier than previous methods. The amount of footprint (carbon dioxide emission) is going down which means this method is more eco-friendly than other methods as well. According to the Cobiax and Hanson Companies, this method brings numerous advantages. The amount of columns needs to support the slabs decreased by 40% (with concrete frame). Total weight cut by 35% which is quite a large volume. The amounts of material used will decrease considerably which will have an effect on the costs. Cobiax balls

cover some areas on slabs therefore the amount of concrete needed will be less which leads to have less transportation cost and required time consumption will drop significantly. Types of Cobiax [3] [1] [6] [8]Reinforced concrete light pre-slab (with balls Cobiax)It is one of the new methods of construction which has many advantages. By using this method, there are no beams required to support the weights (only large spans). The number of columns and total weights will decrease. The concept of this method is to remove the non-working dead load by hollow plastic spheres in the middle of the reinforcement concrete. Meanwhile the flexural strength of slab does not change and allows the biaxial load to transfer. The voids formers or hollow plastic sphere is placed between upper and lower reinforcement layer. There are two types of balls on cobiax method and It depends on the thickness of slabs the shape of balls will be different. Slim-line: for slab range of 20 to 35 cm with depths 100 to 220 mm of these balls are suitable. Eco-line: for slabs range of 35 to 60 cm with depth of 225 to 450 mm these balls are suitable. According to Cobiax Company the advantage of cobiax is that its slabs can be wider and thinner than any other slab in previous methods. The amount of foot-print (or CO2 emission) which could be produce by this method is less, also Cobiax balls can be made from recycled materials and therefore, it is eco-friendly. The whole structure will be more sustainable. In other words, the sustainability in concrete frame will increase. Length of spans could be up to 20m and the soffit is flat which can make a huge range of choices by putting wires and pipes. Total height of building will decrease slightly which is due to the slimmer slabs. For taller buildings it requires less deep excavation because the total weight of building decreases approximately by 35% less than the methods which concrete and reinforcements used. In the

same way, it has few earthquake issues such as reduction in damage risks and also accelerated mass. The issue of costs in this method is that the cost which is spent on bars and concrete will decrease. Reinforced concrete light pre-slab (with plastic shells)[2]It has the same method as the previous method but the difference is that instead of using balls, the prefabricated plastic shells which are produced in factories, have been used. By this method the length of spans could be up to 12. 5 m. The advantage of this method is that is does not required any load-bearing beam. http://www. archiexpo. com

My Design:

In my design I will use the same concept which Cobiax method used. It means that, the amount concrete and the weight of slabs will be reduced by using balls. In other words, in this design I will try to maximise the dead load reduction. However the difference is that the shape of ball will be changed to oval shape. The sizes of balls depend on each situation (loads) and the thickness of the slabs. Upper shape is the shape of matrices and ball. The distance between bars in one axis increased. Lower shape shows the frame which holds the ball. Oval shape increases the capability of design of the ball, which means that the length and height of the balls can be variable. The advantage of this design is that the number of balls will decrease because firstly they are not tandem secondly the length of them is more than cobiax method. By the following reasons the number of balls and time consumption to produce is reducing. Another disparity is that the difference between the depth of slabs and height of voids are in range of 10 to 15 cm which means 100-150 mm concrete should be laid on top and beneath the voids (voids

should be in middle of the slab). I will assume the same range in the design unless I find out the amount of concrete used in the assumption is high. Therefore the depth of slab should decrease. Another reduction is the number of bars for reinforcement which will reduce the bars by 25% and instead of using normal concrete I will use fibre reinforced concrete. As the general advantage and disadvantage of fibre reinforced concrete was mentioned previously now I will discuss each type of fibre concrete in detail; also the weak and strong point of each type will be mentioned. Finally, by comparing the advantages and disadvantages and by taking into account our circumstances that the best types will be selected. The concrete reinforcement ratio is between 110-160 kg for each cubic meter of concrete [6]. (However these records on each situation are different and depend on many facts). The fact is that instead of using bar which is heavy, takes time to deliver it on site and take time to install on right place it is possible to use less reinforcement (sometimes up to 80%) ; also instead of using concrete, FRC is going to be used. Types of fibre reinforced concrete: [1]Steel fibresGlass fibresPropylene fibresSynthetic fibresSteel Fibres [1] [7] [8]Steel has high tensile strength. It improves the strength, freeze-thaw, abrasion and impact resistance of the building. On the other hand, it is easy to shape the fibres. There are different types of steel fibres for different purposes. By adding these kinds of fibres the ductility and durability to undergo the pressures, impact forces will be gain. In addition, steel fibres help to control the cracks by trapping them in a small area and as a result the size of the cracks will be diminished. Glass Fibres [1] [4]Glass fibres are one of the good fibres to reinforce the concrete by them, instead of using the bars which are heavy. GFRC (glass fibre reinforcement concrete) is made from soil;

therefore it is not harmful for environment. Other strong point of these fibres is produce natural chemicals reaction which makes GRFC very strong material and also flexible. it is eco-friendly because the fibre can be made from recycled glass and metal. Propylene Fibres [1] [10] [8]Concrete is not resistant against fire or heat. These fibres can cover this weakness of concrete very well. Propylene fibres has economic price and can increase the compressive strength and thermal resistance. Propylene same as other fibres are decreasing the permeability of concrete and curtail cracks. Propylene melts in 160??? therefore during firing they melt and liquids inside the concrete will evaporate and decrease the pressure inside the concrete. By adding propylene fibres to concrete pump ability over long distances and impact resistance (to any force and plastic shrinkage during curing). Same as steel fibre, propylene fibre increase the freezing thaw of the concrete. As the all advantage and disadvantages mentioned, propylene fibres have many strong point as matter of strength and also the cost. However it reacts to fire quickly which is not suited in many cases therefore propylene fibres is not profitable to use. Synthetic Fibres [8] [9] (Earth magazine, No. 90, Summer 1997)Synthetic fibres are not create by nature or depending on animal farming or agricultural crop, but they made by humans in labs. This fact leads that kind of fibres become cheaper than any other fibres which have natural sources. In the same way, the availability of these fibres is better and also it should have easy maintenance. Synthetic fibres are durable however it dries fast. On the other hands, these fibres have many disadvantages which make some limitation to use them. Synthetic fibres have low melting temperature and will cause to melt before burning. As it mentioned before it is not natural, therefore it is also dangerous for environment. Other

specification of this fibre is to shrink easily and also easily their temperature change (depend on the temperature of area). First of all synthetic fibres is not eco-friendly, however it is cheap and easily produce. The real disadvantages gained by the use of synthetic overrides its disadvantage. As safety matter, the low melting temperature materials (as single or composites) could not be used in buildings. Final decision about fibre reinforced concrete [1]Steel and glass fibre reinforcement are suitable materials which reached required expectation. By adding those fibres to concrete, the strength of concrete will boost. Both of the fibres are eco-friendly, easy to produce, reasonable priced, high tensile strength and resistance to freeze-thaw and heat. The fact is glass fibres are not usually used in slabs however GFRC??? s tensile strength is less than steel (according to Stromberg company). Glass fibres usually use in exterior building fa?? ade panels or in sandwich panels or as architectural precast concrete. Therefore, for walls and facades of the building GFRC will be use. As a result, steel fibres are going to use for slabs.

Plan:

Designs require some assumption in order to calculate the each aspect of the materials. I will try 5 storey office building which has 100m long and 20m width. Next step is the total calculation in order to find out how much force will apply on first floor. Designs should be checked and analysed. It should prove that it will not fail on normal aspects such as the average live loads and dead loads. Then I will work out how this method will affect the strength, ductility and stability. This method has its own advantage and disadvantage

which I will work out in the next step. Finally it would compare with different type of construction.