Design of Futsal Field with Floating Concrete (pontoon)

BY

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I declare that this project is entirely my own work except where due references are made

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2. Abstract

In this project, floating concrete is produced by using normal cement as concrete binder, coarse aggregate and fine aggregate are replaced by mica rock and water with High Range Superplasticiser. To make the lightweight concrete in this research, the conventional aggregate must be modified due to their naturally heavy particles.

In this project, a 1:10 scaled model (0.3m X 0.2m X 0.6m) was designed to stimulate a (30m X 20m X 1m) pontoon that consisted 50% of void. There was trial mixed has been done during the project. Cubes (150mm X 150mm X 150mm) were casted and tested for the compressive strength. The compressive strength of the cubes from the test has reached 10MPa in 7^{th} days, 12MPa in 14^{th} days and 15MPa in 28^{th} days. Design of the court has drawn and loadings are figured out and tabulated. Buoyancy of the pontoon are examined and calculated by using both experimental and formula.

In short, vermiculite is suitable to replace the aggregate as it can achieve 15MPa in 28^{th} days. By using vermiculite as aggregate replacement, the floating pontoon has a load of 1503.12KN while the buoyancy is 2112KN that acting upwards. This lightweight concrete by using vermiculite is capable to support a futsal field.

Content

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Chapter 1 : Introduction

1.1 General

Today, humans seek methods of developing society and improving living conditions (Hosseini, 2009). However, flooding has led to many natural disasters, affecting a great number of people and causing incalculable economic losses. Every year, flooding causes more property damage than any other type of natural disaster (Caraballo-Nadal *et al.*, 2006). There are several different methods for reducing flood vulnerability. One of these flood protection methods is floating urbanization. Floating urbanization can potentially reduce the vulnerability of delta areas. Floating houses adapt to rising water levels and can potentially function as emergency shelter during flood events. Dyson (2006) warned about the increasing risk of flooding, due to global warming in the UK.

Lightweight concrete is defined by (BS EN 206-1:2000) as 'concrete having an oven dried density of not less than 800kg/m^3 and not more than 2000kg/m^3 compared with normal weight concrete which has a density greater than 2000kg/m^3 and typically in the range from 2300kg/m^3 to 2450kg/m^3. The principal benefit in using lightweight concrete is therefore, a reduction in the dead weight of the structure of 15% or more.

The aggregate comprises about 70% of the volume of concrete, so a reduction in density is most easily achieved by replacing all or part of the normal weight aggregate (NWA, that has a density around 2600 kg/m^3) with a lighter weight material and BS EN 206-1 defines lightweight aggregate concrete as concrete 'produced using lightweight aggregate for all or part of the total aggregate'. To achieve a concrete density of less than 2000 kg/m^3 with all of the aggregate replaced by a lightweight material, the particle density of the lightweight aggregate must be also be less than about 2000 kg/m^3, this being equivalent to a dry loose bulk density less than 1200 kg/m^3.

The most benefit from the use of lightweight aggregate concrete is the reduction in dead weight of the structure, which may lead to potential savings like reinforcement and prestressing steel; transportation and handling aggregates of precast elements and also can reduce formwork and propping for in-situ construction. For example, benefit of weight saving is most apparent for structures with high dead to live load ratio like long-span bridges, flyover bridges and etc.

Another benefit for the use of lightweight aggregate is manufactured from waste materials and reduces the use of the limited resources in Earth. In this project, vermiculite is chosen as the aggregate replacement because it is formed by alteration which is a product of mica and other minerals that can reduce in the use of primary aggregates, with the associated saving in aggregate levy.

The use of lightweight concrete is not new. It has been available only since the early part of the 20th century. In recent years, lightweight aggregate concrete has been used in a wide range of structural applications including bridges, buildings, floating docks, gravity bases for offshore oil platforms and stadium, demonstrating both its structural capability and its durability in some very aggressive environments.

The purpose of doing this project is because expensive land acquisition and reduce environmental impacts. Under this title, a floatable lightweight concrete was designed to withstand a futsal filed on top of it. The challenge of this project was to design and make a floating concrete by using vermiculite as aggregate replacement.

1.2 Problem Statement

With the increasing demand and the non-availability of natural lightweights aggregate worldwide, techniques have been developed to produce them in factories. Today, lightweight aggregates are produced in a very wide range of densities varying from 50 kg/m3 for expanded perlite to 1000 kg/m3 for clinkers. With these aggregates and high range water reducers, it is possible to make LWAC of 80 MPa 150mm cube compressive strength. Because of the practical advantages which it possesses, lightweight aggregate concrete has, in recent years, become an important structural material and the demand for it is increasing. A savings in the weight of the superstructure means that foundations can be reduced in bulk, and time and expenses saved in erection and handling of components, so that smaller lifting equipment can be employed or larger precast units can be handled.

Due to its low density, lightweight aggregate like vermiculite is chosen to replace aggregate to construct a floating concrete. Dead load of the structure is reduced due to the low density materials used. There are some precautions to notice before casting of the cubes. Vermiculite is mica with a platy structure and it will expand when heated at a high temperature. All grades of exfoliated vermiculite will retain liquids within the inter-laminar voids of the individual particles as well as between the particles themselves. Therefore, a large amount of water needs to be prepared during the mixing of concrete and the amount of fine vermiculite will be reduced to lower the chance for the water to be absorbed. During the pouring of the concrete, cubes and pontoon are advised not to compress too hard to maintain the original structure of vermiculite. Bleeding and segregation that usually occur with high workability mixes can be avoided if concrete mix design, production and handling are controlled properly.

1.3 Objective

- To study the use of vermiculite(mica rock) as aggregate replacement.
- To design a floatable lightweight concrete
- To design a futsal field on the top of floating concrete.

1.4 Scope of work

- Vermiculite (mica rock) as aggregate replacement in the lightweight concrete.
- The size of pontoon and concrete cube were fixed at (500mm X 500mm X100mm) and (100mm X 100mm X 100mm), respectively.
- The concrete cubes were tested by compression test and pontoon was tested on floating test (buoyancy and stability) ONLY.
- There is only 1 futsal field was designed on the floating concrete.

Chapter 2 : Methodology

2.1 *Materials Used to make lightweight Concrete*

2.2.1 Vermiculite

Vermiculite is the mineralogical name given to hydrated laminar magnesium-aluminum iron silicate which resembles mica in appearance. It is formed by alteration or the selective replacement of ions in a structure without destroying the structure (e.g. micas are altered to vermiculites). Layer spacing ranges from 1.0 to 1.5 nm or more.

Vermiculite is a versatile mineral which can be develop into many different kinds of beneficial products, because of its thermal stability and inertness. Vermiculite can be said is clean to handle, easy to use, light weight, odorless, non-toxic and not harmful to environment.

When analysed chemically, crude and exfoliated vermiculite give the same values. Because vermiculite is a naturally occurring substance its exact composition may vary from sample to sample.

Vermiculite		**Crude Vermiculite**		**Exfoliated Vermiculite**
No	**Grade**	**Size (mm)**	**Density (kg/m³)**	**Density (kg/m³)**
1	**Large**	**-3.0+7.0**	**1400-1600**	**140-170**
2	**Medium**	**-4.0+1.4**	**1200-1400**	**130-150**
3	**Fine**	**-2.0+0.7**	**1150-1350**	**120-145**
4	**Superfine**	**-1.0+0.35**	**1100-1300**	**110-140**

Table 1 : Typical Specification for Crude and Exfoliated Vermiculite

2.2.2.1 The General Application of vermiculite (Reference)

- Fireproofing Vermiculite Spray
- Horticulture or Packing Material
- Brake Friction Materials

2.2.2 Cement

Cement is a binder, a substance that sets and hardens and can bind other materials together. The word "cement" traces to the Romans, who used the term opus caementicium to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder. The volcanic ash and pulverized brick supplements that were added to the burnt lime, to obtain a hydraulic binder, were later referred to as cementum, cimentum, cäment, and cement.

Ordinary Portland Cement (OPC)

Ordinary/Normal Portland cement is one of the most widely used types of Portland Cement. It relies on a high-energy manufacturing process that imparts high potential energy to the material via calcination. This means the activated material will react readily with a low energy material such as water.The chief chemical components of ordinary Portland cement are:

- Calcium
- Silica
- Alumina
- Iron

Table 2.: Basic Component

Contents	%
CaO	60-67
SiO2	17-25
Al2O3	3-8
Fe2O3	0.5-6.0
MgO	0.5-4.0
Alkalis	0.3-1.2
SO3	2.0-3.5

2.3 Superplasticiser (MasterGlenium ACE 8109)

[(Formerly known as Glenium® ACE 309)]

An innovative polycarboxylic ether (PCE) based Superplasticiser that has super retention technology. Due to a specifically tailored constitution of the active material, this admixture shows formerly unknown adsorption characteristics to cement.

Benefits for the precast concrete industry:

- Produce Rheoplastic and Self Consolidating Concrete with a low water/cement ratio
- Optimize curing cycle by shortening curing time or decreasing curing temperature
- Eliminate heat curing and energy required for placing, consolidation and curing
- Increase productivity and improve surface appearance
- Produce durable precast concrete elements
- As compared to the traditional Superplasticiser, improve engineering properties such as early and ultimate compressive and flexural strengths.

Application of Superplasticiser

Liquid admixture will be added to the concrete during the mixing process. The best results are obtained when the admixture is added after all the other components are already in the mixer and after the addition of at least 80% of the total water.

2.4 Step of Mixing

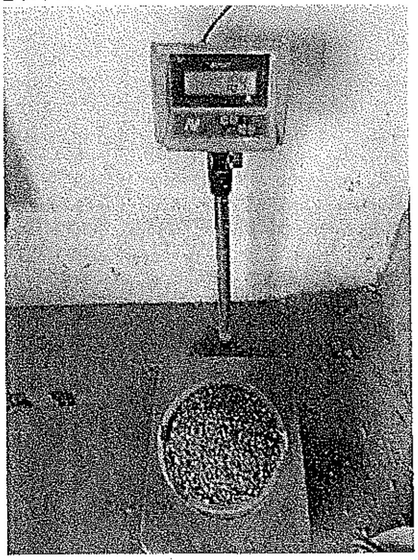
- **Make the mould:** Use plywood planks and nails to make a one side open box with an inner cavity of 300mm (length) x 200mm (width) x 150mm (thick) as the standard size of a concrete brick. The wooden mold was initially oiled.

- **Prepare the concrete mix:** Get a large container, as large as can get in the work area. Cement, sand, gravel, and water were required for making the concrete mix. Put the cement, sand, and gravel in the container that following the mix proportion. Mix Proportion was shown in Table 5(pg 17). Start mixing water in the container and stir the mixture continuously with a rod. Pour water until the concrete mixture become pliable enough to pour in the mould.

- **Making the raw concrete block:** Pour the concrete mixture in to the mould, and stir or vibrate the mould so that the concrete gets settled in the mould and reaches the extreme corners. Scoop the excess concrete mixture using a plywood plank at the open face of the mould. Level the open surface smooth by running the plywood plank across it.

- **Curing and Testing:** The concrete blocks need to be kept in the mould for 24 hours for drying. Then remove the concrete block from the mould and put it in a water tank for curing. The curing process will provide the required compressive strength and will take at 7^{th}, 14^{th} and 28^{th} days respectively.

Photos



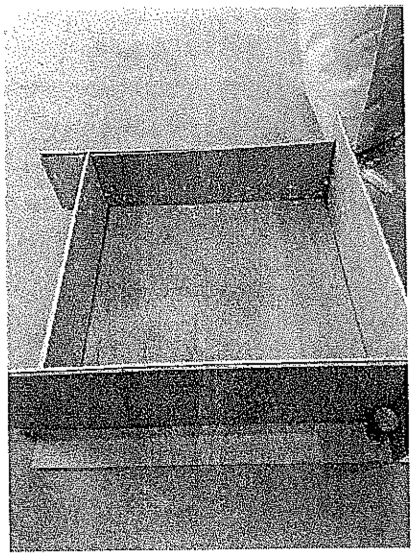


Photo 1,2,3 & 4

Materials like cement, vermiculite and formwork are prepared well-mixed by using machine and weighed before casting. Mix proportion is calculated before entering the lab.

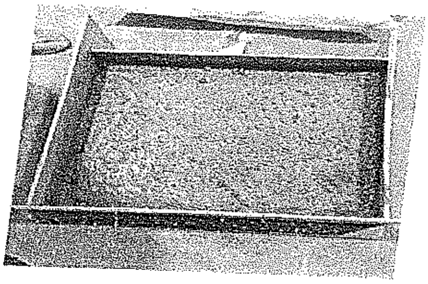


Photo 5 : Poured the mixture into formwork and cube mould and let it to harden itself.

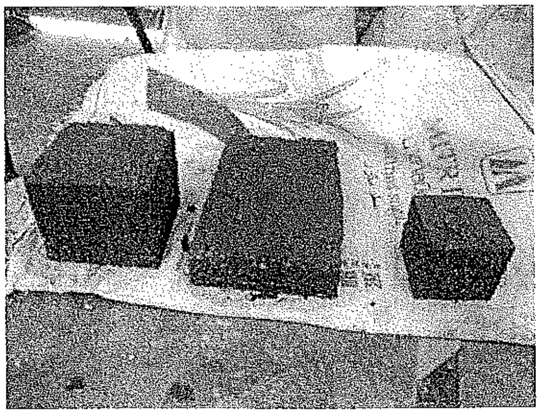


Photo 6 : The cubes and pontoon are demoulded and covered by guni bags to them to air-cured.

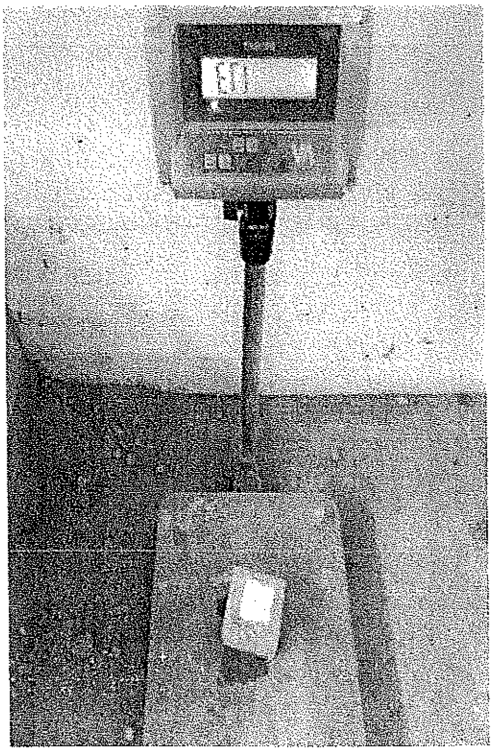


Photo 7
Cubes are weighted before starting the compression test.