Review On Stratified Concrete Wall Panels

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Abstract - Concrete is the most important, unavoidable and versatile construction material. The Conventional Concrete is a poor thermal insulating material, by comparing the Light Weight Concrete (LWC) provides good insulation in thermal properties and it will absorb high thermal energy and release it, when the internal temperature drops below in the concrete. The stratified concrete panels belongs the light weight category and it poses a promising alternative solution for the construction. It has limited thermal mass but it is excellent insulating property when compared to commercial type. The stratification is achieved by vibrating the concrete in different density. The panels are made by using waste and recycled materials such as Fly-ash, Expanded Polystyrene, Expanded Glass Beads, Slag and Silica fume. In this paper, the literature study has been done in the structural behavior of the stratified wall panels and conventional wall panels with appropriate testing methodology.

Keywords - LWC, Stratified Concrete, Thermal Insulation etc.

INTRODUCTION

Stratified Concrete is produced from a single concrete mixture which is controlled segregated by vibration to produce a normal-weight concrete layer and a lightweight concrete layer. Normal-weight concrete provides the benefit of high compressive strength and thermal mass but has little insulating ability. On the other hand, lightweight concrete offers limited compressive strength and thermal mass but has excellent insulating properties due to its high air content.Stratified concrete specimens are made by combining different concrete layers. To achieve this, a single mix containing both lightweight and normal-weight aggregate is cast and vibrated within the formwork to produce a controlled segregation. This process forms a normal-weight concrete (NWC) layer and a lightweight concrete (LWC) layer. NWC provides the benefit of thermal mass but has little insulating ability. LWC in comparison offers limited thermal mass but has excellent insulating properties due to its low density and high air content Building envelope comprising both these layers can provide both thermal mass and insulating properties, leading to a considerable reduction in heating and cooling costs.Lightweight concrete can be produced by using lightweight aggregate or by aeration. One of the advantages of lightweight concrete is a good thermal insulating property, but other equally important properties are for example reduced mass while maintaining adequate strength, good durability and good sound insulation.The use of lightweight concrete is energy saving in many ways that is, less energy is required for heating over the lifetime of the building and reduced weight reduces the energy demand during construction. The greater the density of lightweight aggregate concrete the higher the thermal conductivity and strength but lower thermal insulation is provided by the concrete.Thermal mass is a property of the material that enables it to absorb and store thermal energy within its mass. This means that the concrete will absorb heat when the room is hot, store it, and then release it once the internal temperature drops below that of the concrete. This results in cooler feeling rooms in summer and warmer rooms in winter. This means the temperature spikes are removed; interior temperature remains within a comfortable living temperature.The use of precast stratified panel systems offers the opportunity to control the quality of the end product to a very high degree, because the panels are supplied from specialized precasting factories and therefore cast in controlled environment. This fact is very important for stratified concrete specimens, due to the vibration process must be controlled to achieve a correct stratification.The separation is defined as the overwet or overvibratedconcrete.Into horizontal layers with increasingly lighter material toward the top. Water, laitance, mortar, and coarse aggregate will tend to occupy successfully lower position in that order.A layered structure in concrete resulting from placing of successive batches that differ in appearance.

EPS (Expanded Polystyrene) or as many know by Polystyrene is normally a solid thermoplastic at room temperature that can be melted at a higher temperature and re-solidified for desired applications.The expanded version of polystyrene is about forty times the volume of the original polystyrene granul.Polystyrene foams are used for a variety of applications because of its excellent set of properties including good thermal insulation, good damping properties and being extremely light weight. From being used as building materials to white foam packaging, expanded polystyrene has a wide range of end-use applications. In fact, many surfboards now use EPS as the foam core.EPS is inert in nature and therefore does not result in any chemical reactions. Since it will not appeal to any pests, it can be used easily in the construction industry. It is also closed cell, so when used as a core material it will absorb little water and in return, not promote mold or rotting.EPS is durable, strong as well as lightweight and can be used as insulated panel systems for facades, walls, roofs and floors in buildings, as flotation material in the construction of marinas and pontoons and as a lightweight fill in road and railway construction.EPS is completely recyclable as it will become polystyrene plastic when recycled.

Expanded glass beads is 100 % mineral and combines low density with a high compressive strength. Expanded glass beads (also referred to as cellular glassor foam glass) is a heat-insulating material consisting of sealed glass bubbles, which do not communicate with each other.Expanded glass beads (also referred to as cellular glass or foam glass) is a heat-insulating material consisting of sealed glass bubbles, which do not communicate with each other. Foam glass has a closed-cell structure, which ensures steam-proofness and water resistance. The structure resembles solid soapsuds. The cells have spherical or hexagonal shape,their size can vary from fractions of millimeters to centimeters.Like any glass, foam glass is insoluble in water, stable to the majority of acids and organic solvents, and can withstand high temperatures. Principal unique properties of foam glass as compared to conventional thermal insulation materials include low thermal conductivity, high strength, ease of processing and installation, environmental safety, and durability. Expanded glass beads is used in plant substrates and soils to improve the air and water capacity.It is perfectly suitable for decorative purposes.

NEW INSULATING PRECAST CONCRETE PANELS

James R. Mackechnieet al(11) studied a new type of insulating precast concrete wall panels. These panels combine the properties of lightweight insulating and heavy/normal weight concrete. Conventional concrete is a poor insulating material but has good thermal mass while lightweight concrete provides good insulation at the price of thermal mass. In this method they choosed lightweight concrete top (outside) layer and a heavy/normal weight concrete dense bottom (inside) layer. These layers were gained by controlled segregation or stratification. The stratification was achieved by vibration using aggregates of different density and a moderately sticky paste. These panels were manufactured with a simple and energy efficient processes using mostly recycled materials s such as fly ash, slag and expanded glass beads together with either Portland cement or inorganic polymer cements. Finally they researched that the Energy is saved over the lifetime of the building, by using less energy in heating . This would also save the use of other insulating mediums that are not ideal in terms of energy efficiency and prevent the full thermal mass of concrete being utilized. The concept is therefore to build from our waste instead of putting it into landfills. These panels are going to be simple in construction they are also energy saving during the life time of the building by providing good insulation and thermal mass.

THERMAL INSULATING CONCRETE WALL PANEL DESIGN FOR SUSTAINABLE BUILT ENVIRONMENT

Ao Zhou et al(10) Investigated a new design of concrete wall panel that enhances thermal insulation of buildings by adding a gypsum layer inside concrete is presented and they were monitored the temperature variation in both proposed sandwich wall panel and conventional concrete wall panel under a heat radiation source . In order to save the vast energy consumed by air-conditioning system, such that the unwanted heat gain and loss with environment can be minimized.. Three different types of sandwiched layers were adopted in this experiment, namely, concrete layer, solid gypsum layer, and gypsum layer with voids. Compared with the conventional precast concrete wall panel, the new sandwich concrete or gypsum wall panel. The voids in the gypsum panel were introduced by placing 9 polystyrene foam cubes in the mold during the casting process, and the polystyrene cubes were removed after the hardening of gypsum. A halogen lamp was used for thermal testing. Only the outer surface of the specimens was illuminated and the sides of specimens were prevented from heating. The temperature of both the illuminated and the unilluminated concrete layers were measured in a one minute interval using the thermocouples embedded at the center of each panel. Experiments have been performed to validate that the sandwiched gypsum layer can effectively retard the heat transfer process in the precast concrete wall panel and the gypsum layer with voids possesses the greatest thermal insulating capability among the tested specimens. Meanwhile, the thermal conductivities of concrete and gypsum have been carefully evaluated through the parametric studies, as these properties play an important role in the heat transfer process simulation of the building models and finally noticed that the interior surface of the building adopted in the sandwich concrete/gypsum wall panel is 1.1∘ C lower than that of the convention concrete building, implying that the electricity consumed by air-conditioning system can be saved remarkably when the proposed sandwich concrete/gypsum wall panel is adopted as building envelope.

EXPANDED POLYSTYRENE AGGREGATE CONTAINING SILICA FUME AND POLYPROPYLENE FIBERS

Chen Bing et al(13)Investigated the effect of Expanded Polystyrene aggregate containing silica fume and polypropylene Fibers in concrete. They developed a new structural lightweight concrete by totally or partially replacing coarse and fine aggregates in high performance concrete by expanded polystyrene (EPS) beads. Polystyrene beads are a widely used aggregate and can be easily incorporated into concrete or mortar to produce light-weight concrete with a wide range of densities. In this work, they used the sizes of EPS bead were 1.0, 2.5 and 6.3 mm. Cubes of 100 mm^3 size were used for studying the compressive strength at 3, 7, 14 28 and 60 days and also for the absorption tests at 60 days. Splitting tensile strength test was conducted on cubes of 100 mm^3 at the age of 28 days. Prisms of 100 mm×100 mm×515 mm were used for shrinkage testing at 3, 7, 14, 28, 60 and 90 days. Compressive strength, splitting tensile strength, shrinkage, and water absorption were examined. Additionally, fine silica fume (SF) and polypropylene (PP) fibers were added to improve the mechanical and shrinkage properties of EPS concretes. The results show that fine SF greatly increases the bond strength between the EPS beads and cement paste, thus increasing the compressive strength of EPS concrete. With inclusion of Polypropylene Fibers(PP) fibers, drying shrinkage properties are significantly improved. Structural lightweight concretes of density of 1370-1 950 kg/m^3 and the corresponding strengths of about 20-40 Mpa are successfully developed. Lightweight EPS concretes with a wide range of concrete densities and compressive strengths was successfully developed.

LIGHTWEIGHT EXPANDED POLYSTYRENE BEADS CONCRETE”

AmanMulla et al(3) Investigated the effect of Expanded Polystyrene Beads in concrete they did concrete mix proportion which gives better results than the Burnt Brick (compressive strength and density), and studied the properties, such as density, compressive strength and splitting tensile strength of lightweight Expanded Polystyrene (EPS) beads concrete. Then its properties are compared with M20 grade conventional concrete. They were used the materials is locally available and these included PPC (fly ash based cement) as a binding agent, river sand as fine aggregates, crushed coarse aggregates(less than 4.75 mm) and EPS beads. Potable tap water was used for mixing and curing throughout the entire work. Three Concrete samples are taken from three different mix proportions. Workability Test (Slump Cone Test), Split Tensile Strength Test, Compressive Strength Test are tested in the samples. Finally they found that the EPS concrete gives good workability and could easily be compacted and finished. Workability increases with increase in EPS content. The compressive strength of EPS concrete is less than Conventional concrete. The concrete mix of TYPE-A having lowest density and it gives the strength more than Burnt Brick so this concrete mix proportion was useful as Lightweight concrete Brick in construction work. They observed for mix proportion, the mix proportion of TYPE-B gives more strength as 15 Mpa and density nearly as a brick and also gives tensile strength more than normal concrete so this TYPE-B mix proportion concrete was also used filling material in slabs concreting. The designed all mix proportions are useful in cladding panels and tilt up panels. The concrete mix proportion also useful as precast concrete members with low density and more workability.

STRATIFIED LAYER BUILDING SYSTEMS

M. Imperadori et al(2012)studied the uses of Stratified Layer Building system they researched the guaranty of flexibility, as well as a possibility of disassembling and reuse or recycle of components in a building system. This is deals with lightweight buildings composed by structures and addition of independent layers , choosen to give focused performances and built on site Lightweight buildings are conceived as "high environmental tech", because they create cycles of use. Every part of them could be substituted, reused or recycled with low consumption of energy at finally they gived the opinion that the use of materials available on the market and industrially produced gives the opportunity to have quality products. The use of them in dry systems allows to reduce the uncertainity of behaviour due to uncontrollable on site elaboration.

THE STRUCTURAL, SERVICEABILITY, DURABILITY PERFORMANCE OF VARIABLE DENSITY CONCRETE PANELS

Saevarsdottir T. (2008)investigated the research to estimate the hardened performance; that is the structural, serviceability and durability performance of the variable density concrete panel. Further developments to the mix design were made where the fresh properties were measured and thermal performance estimated on hardened specimens. Most of the major technical concerns were proved not being as severe as first thought, making the production of variable density concrete panels promising. To ensure that the variable density concrete would stratify, the concrete mix had to have defined fresh properties. Defined rheological ranges gave a good indication of the stratification potential, but the degree of stratification was also found to be dependent on the intensity and time of vibration. Slump flow had to be within a certain range to achieve good stratification but this alone did not guarantee stratification. Variable density concrete was found to have adequate strength capacity both in axial compression and in tension for likely service loads but the strength required to withstand handling loads at early ages was not assessed. The strength of the variable density concrete was found to be affected by several factors such as; degree of stratification, relative strength and thickness of the layers, curing environment and amount of defects. As the stratification of the concrete increased the thermal insulation improved whereas the strength decreased. Warping was found not to significantly affect the serviceability of panels despite differential shrinkage within the element. The amount of warping was mainly related to the degree of stratification. Warping decreased with better stratification as more stress and strain was relieved in the lightweight layer. The lightweight concrete was significantly weaker as well as being less stiff than the structural concrete and therefore creeps to follow the structural concrete. The thermal properties aimed for were generally not reached, but these mixes were not designed to optimise the thermal performance and were tested before the concrete was fully dried. This increased thermal conductivity and therefore reduced the measured R-values. Stratified concrete had good absorption resistance, poor permeability properties and was highly porous. If the concrete was over-vibrated it tended to have a rough surface finish that would require a coating. Delamination of the panels was not assessed in this research but is a likely mode of failure.

INFLUENCE OF SILICA FUME ON CONCRETE

Vishal S. Ghutke et al(2014)investigated the effect of silica fume on concrete. Silica fume is a byproduct and it is the most beneficial uses in concrete. Because of its chemical and physical properties, it is a very reactive pozzolanathey gave to understand the effect and have an overlook of Silica Fume on Concrete. In this paper the advantages of using silica fume in concrete in partial replacement of cement are found. .Silica fume is a byproduct and it is the most beneficial uses in concrete. Because of its chemical and physical properties, it is a very reactive pozzolana.the silica fume contains Contains more than 90 percent silicon dioxide Other constituents are carbon, sulphur and oxides of aluminium, iron, calcium, magnesium, sodium and potassium The physical composition are Diameter is about 0.1 micron to 0.2 micron Surface area about 30,000 m^2/kg Density varies from 150 to 700 kg/m^3. They were used the mix proportion of M 20 grade of concrete, the quantities of materials used for two w/cm ratio are worked out. Four types of concrete mix are prepared, the first one (type I) was conventional concrete (0% Silica Fume) with w/cm ratio 0.5, the second one (type II) was conventional concrete (0% Silica Fume) with w/cm ratio 0.6, the third (type III) was combination of Portland cement and various % of silica fume (5%, 10%,15%, 20% and 25%) with w/cm ratio 0.5 and the fourth one (type IV) was combination of Portland cement and various % of silica fume (5%, 10%,15%, 20% and 25%) with w/cm ratio 0.6. Three specimens were tested for 3, 7 & 28 days with each proportion of silica fume replacement. The result shows that the workability of concrete reduces with increase in silica fume content of concrete. The workability of silica fume concrete differs from conventional concrete. With the increase in w/cm ratio strength of concrete decreases. The optimum value of compressive strength can be achieved in 10% replacement of silica fume. As strength of 15% replacement of cement by silica fume is more than normal concrete. The optimum silica fume replacement percentage is varies from 10 % to 15 % replacement level. Workability of concrete decreases as increase with % of silica fume. Compressive strength decreases when the cement replacement is above 15% of silica fume. From the results it is known that the silica fume is a better replacement of cement. The rate of strength gain in silica fume concrete is high.

PROPERTIES OF SEMILIGHTWEIGHT SELF-CONSOLIDATING CONCRETE

JacekKwasny et al(2013) studied the properties of fresh and hardened semilightweight self-consolidating concrete (SLWSCC) mixtures, produced with two types of manufactured coarse lightweight aggregates (LWA) and normal weight sand. The first type, a sintered pulverized fuel ash, was made from an industrial by-product, fly ash, whereas the second one, an expanded clay, was produced from a naturally sourced clay. For all mixtures, normal weight sand was used as a fine fraction of aggregates, and the portland cement was partially replaced with a limestone powder. The SLWSCC was produced with different water presaturation regimes of the LWAs. The desired initial slump-flow spread was set between 700 and 800 mm. The effect of three superplasticizers was evaluated by testing properties of SLWSCC, normal weight SCC, and paste mixtures. Three SCC fresh properties were measured: the slump-flow, the V-funnel flow time, and the J-ring blocking step. Moreover, the slump-flow loss was evaluated. The degree of segregation was assessed in both fresh and hardened states. Additionally, the hardened density and the compressive strengths were tested. All SLWSCC mixtures were produced with a desired range of slump-flow spread and with satisfactory passing ability assessed with the J-ring test.A preliminary investigation was conducted according to BS 812- 2:1995 (BSI 1995) to determine the 30-min and 24-h water absorption of both types of LWAs, and 24-h water absorption for NWS. The evolution of the water absorption of the LWAs over a sevenday period (5, 15, 30, 60, 120 min, 24 h, and further measurements at 24-h intervals) was investigated.After the seven-day measurement sintered pulverized fuel ash LWA. Only mixtures containing SP-3 superplasticizer showed acceptable workability loss resistance The SCC mixtures were prepared in a Croker Cumflow 160 kg capacity rotating pan mixer, in 30-L batches. Initial slump-flow test and slump-flow test repeated after 30 min . The slump-flow spread and time for the SCC spread to reach a diameter of 500 mm were measured. The testing procedure was continued. For a slump-flow spread of more than 800 mm, the mixture was reproduced with a lower SP dosage. Counting from the moment cement was mixed with the water, the time for reaching anSFin of 700–800 mm was noted (between 5 and 11 min for the the second or third dosages of SP). Thirty minutes later, the slump-flow test was repeated (SF30). V-funnel test: the SCC rate of flow (viscosity) was measured with the V-funnel test, which began between 7 and 13 min, and was conducted. J-ring test: the passing ability of the SCC was evaluated with a Jring test that began between 9 and 15 min. A J-ring apparatus with a wide gap (59 mm) and one with a narrow gap (41 mm) were used for SLWSCC made with LWA-1 and drying was used to calculate the amount of the surface moisture (as an average of the two results). After determining the surface moisture content, LWA-1 samples were dried in the oven (105 5°C) until a constant mass was obtained. Finally the result was The mixture design, which considered the packing of all solids used in the SLWSCC, enabled the production of a highly flowable concrete, with a slump-flow of 700–800 mm, without VMA and with an excellent passing ability (J-ring blocking step less than 10 mm). Mixtures with a slump-flow of more than 720 mm might require the use of the VMA to increase stability The SSD density of mixtures varied between 2,025 and 2;125 kg=m^3

EFFECT OF SILICA FUME ON STRENGTH AND DURABILITY PARAMETERS OF CONCRETE

N. K. Amudhavalli(2012) investigated the EFFECT OF SILICA FUME ON STRENGTH AND DURABILITY PARAMETERS OF CONCRETE the suitability of silica fume has been discussed by replacing cement with silica fume at varying percentage and the strength parameters were compared with conventional concrete. The workability of the concrete was measured by conducting slump cone test and compaction factor test . The trials were carried out to improve the workability and cohesiveness of the fresh concrete by incorporating a super plasticizer. Marsh cone test was conducted to select the better combination of water, cementitious materials and chemical admixtures. Mortar mixture was prepared and the saturated point was determined using a marsh cone with a nozzle having an opening of 5mm diameter and 50mm length. The time taken for the first 200ml of cement paste to flow through the cone was measured. This is called flow time. Three flow times were measured for each paste and mean value was used. The specimen of standard cube of (150mm x 150mm x 150mm) and standard cylinders of (300mm x 100mm) and Prisms of (150mm x150mm x 750mm) were used to determine the compressive strength, split Tensile strength and flexural strength of concrete. Three specimens were tested for 7 & 28 days with each proportion of silica fume replacement. Totally 30 cubes, 30 cylinders and 30 prisms were cast for the strength parameters and 15 cubes for acid attack test. The constituents were weighed and the materials were mixed by hand mixing. The water binder ratio (W/B) (Binder = Cement + Partial replacement of silica fume) adopted was 0.36 and weight of super plasticizer was estimated as 0.65% of weight of binder. The concrete was filled in different layers and each layer was compacted. The specimens were demoulded after 24 hrs, cured in water for 7 & 28 days, and then tested for its compressive, split tensile and flexural strength as per Indian Standards.finally the result was Silica fume is having greater fineness than cement and greater surface area so the consistency increases greatly, when silica fume percentage increases. The normal consistency increases about 40% when silica fume percentage increases from 0% to 20%. The optimum 7 and 28-day compressive strength and flexural strength have been obtained in the range of 10-15 % silica fume replacement level. Increase in split tensile strength beyond 10 % silica fume replacement is almost insignificant whereas gain in flexural tensile strength have occurred even up to 15 % replacements. Silica fume seems to have a more pronounced effect on the flexural strength than the split tensile strength. When compared to other mix the loss in weight and compressive strength percentage was found to be reduced by 2.23 and 7.69 when the cement was replaced by 10% of Silica fume.

THERMAL PERFORMANCE OF VARIABLE DENSITY WALL PANELS

J. Kosny et al(2015)studied the energy performance of light-weight and massive wall systems.Theyestiamated the potential energy benefits of residential building using thermal mass. Dynamic thermal performance of sixteen wall assemblies was investigated for residential buildings and the potential energy savings were presented for ten U.S. climates. It was found that some massive building envelope technologies can help in the reduction of building annual energies. Comparative analysis of sixteen different material configurations showed that the most effective wall assembly was the wall with thermal mass (concrete) applied in good contact with the interior of the building. Walls where the insulation material was concentrated on the interior side, performed much worse. Wall configurations with the concrete wall core and insulation placed on both sides of the wall performed slightly better, however, their performance was significantly worse than walls containing foam core and concrete shells on both sides. Potential energy savings are calculated for ten U. S. climates. Presented research work demonstrate that in some U. S. locations, heating and cooling energy demands for buildings containing massive walls of relatively high R-values can be lower than those in similar buildings constructed using lightweight wall technologies.

SUMMARY AND CONCLUSIONS

This paper has introduced stratified concrete wall panels and its sustainability towards structural performance. All the experimental and theoretical values set in motion by the authors since 2016 have been bestow from the structural elements and overall building point of view.

By using the variable density panels we are getting closer in becoming sustainable due to the facts that:

- Energy is saved over the lifetime of the building, by using less energy in heating.
- These panels have been designed using recycled materials or by-products from other industries. The concept is therefore to build from our waste instead of putting it into landfills.
- Further research is being carried out but it shows promising potential of producing the variable density concrete panels. These panels are going to be manufactured with a simple and energy efficient processes using mostly recycled materials. As well as being simple in construction they are also energy saving during the life time of the building by providing good insulation and thermal mass.

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