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Effect of Layered Double Hydroxide (Mg-Al) Reinforced in Concrete for Enhancing Thermal Comfort

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Abstract: Experimental study was done on the effect of layered double hydroxide (LDH) Magnesium-Aluminium (Mg-Al) on M20 grade concrete. Different weight percentage (0.5, 0.75, 1.0 & 1.25 Weight percentage of cement) of MgAl LDH as nano material was added with cement concrete cubes. These cubes were tested for X-ray diffraction (XRD), temperature absorption measurement and compressive strength. The XRD pattern of the concrete cubes shows the presence of MgAl LDH without any reaction with concrete. To find the compressive strength of the M20 concrete cubes contains with MgAl LDH, compressive strength test was performed. The experimental investigation shows the optimum percentage of MgAl LDH to be added for giving maximum temperature absorption without affecting the compressive strength and it is proved from the result that there is absorption of temperature to improve the thermal comfort.

Index Terms: MgAl LDH, XRD, M20 Concrete & Compressive Strength

I. INTRODUCTION

The supply of the overall energy consumption becomes tense gradually since the world economic growth has become rapid. As we know that in the building sectors energy consumption is the predominant and it accounts to a total of 40% share of the overall energy consumption [1-3]. This lead the construction industry to look for energy saving material for energy conservation and greenhouse gas emission reduction. In the present construction industry materials like steel, aggregates and water are sensible heat absorbing and storing material which absorbs and stores thermal energy when the temperature is increased [4-8]. The advancement of new or adjusted cement is an imperative piece of existing techniques to enhance execution and limiting the life-cycle costs. The utilization of strengthening cementitious materials in cement is an essential part of these systems [9-11]. Ecological issues are additionally of worry to both the bond and development enterprises. MgAl LDH materials are referred to as latent heat storage materials because of its fireretardant property [12-14].

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MgAl LDH is an inorganic material having high volumetric latent heat storage capacity, non-flammable and available at low cost. MgAl LDH is capable of storing and releasing of large amounts of heat energy [15-18].
Magnesium hydroxide and Aluminum hydroxide is an inorganic flame resistant because of their high warmth sink limit [19, 20]. The admixture of MgAl LDH to concrete also absorbs the carbon dioxide (CO2) thereby reduces the corrosion effect on reinforced cement concrete, and it leads to reduction of green house effect [21-26].

In bond science, the job of layered twofold hydroxide and MgAl LDH family materials were explored, further they tended to the reasonability of intercalating chosen natural atoms of importance to the solid business [27]. The most fascinating properties of these layered twofold hydroxides are High explicit surface region, Homogeneous scattering, Synergetic impacts between the components, Exfoliation happens when the mineral is warmed adequately and "Memory impact", which permits recreation under gentle conditions (after calcination until 500 °C) of the first structure by contact with arrangements containing different anions [28-29].

With this endeavour, this present study MgAl LDH is tested for the latent heat storage material to improve the thermal comfort of the concrete building. XRD analysis was carried out to find the presence of MgAl LDH nano material in concrete cubes with and without MgAl LDH. MgAl LDH is low cost readily prep arable material and used as latent heat storage material, it reduces the cost of energy efficient buildings.

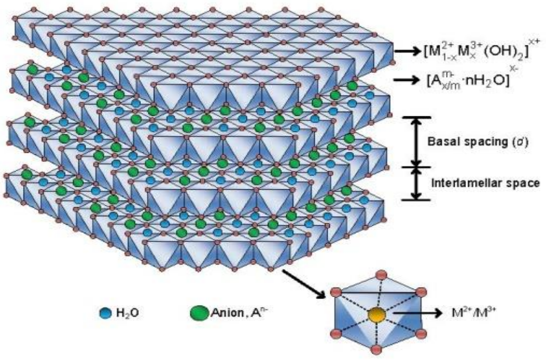

Fig. 1. Schematic diagram of a typical LDH structure [30].

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II. EXPERIMENTAL PROCEDURE

A. Synthesis of MgAl LDH:

A basic solution of $Mg(NO_3)_2.6H_2O$ (0.21M, 70mM) and $Al(NO_3)_3.9H_2O$ (0.06M, 20mM) i.e., in molar ratio Mg/Al=3, was prepared in water (50ml) which was mixed homogenously in a two neck RB flask placed on a magnetic stirrer, kept at 500rpm, with a heating temperature of 60oC. The reaction was carried out in constant N_2 atmosphere to prevent the inclusion of carbonate ions from atmospheric air. The pH was maintained at 12, by drop wise addition of ammonium hydroxide solution. After 24h reaction time, the resultant white precipitate was dried in oven at 50oC for 24h and stored in a vacuum desiccator for further analysis. Submit your manuscript electronically for review.

B. M20 Grade Concrete Mix

In view of ISO: 10262:2009 technique, the extent of constituents of cement was determined for M20 grade concrete. The amount of materials for a volume of 1 m^3 of cement was taken as 382 Kg of bond, 644 Kg of fine total, 1240 Kg of coarse total and 181.6 liter of water. For improving the thermal comfort of the concrete cubes, MgAl LDH was chosen as latent heat storage material admixture. Option of MgAl LDH was chosen as far as different rates (0.5, 0.75, 1.0 and 1.25 on weight level of bond) and after that the admixture was added to the totals for the readiness of concrete cubes. Homogenous blending of MgAl LDH with bond concrete was safeguarded.

C. Design Positioning of Thermocouple in Concrete Cube

For measuring the temperature of normal concrete and MgAl LDH incorporated concrete K-type thermocouple was used as a sensor. For estimating the temperature variety inside the concrete cubes 'K-type' thermocouple was fixed in the middle and side of the shape before the giving of solid 3D shapes a role as appeared in Fig.2, The temperature was estimated utilizing an indigenously made digital thermometer which has an advanced LED showcase as appeared in Fig.3. It was manufactured so that it could quantify the temperature inside the concrete cube. Digital Thermometer has a digital LED display with 12 segments. It is able to display the temperature from -150℃ to +1340℃.

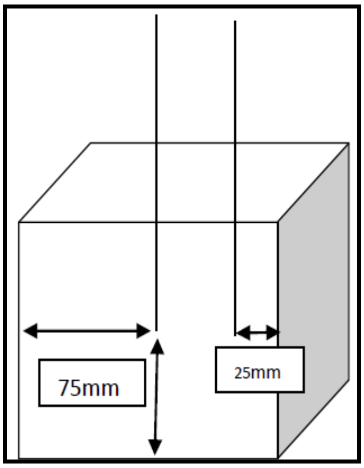

Fig. 2. Position of thermocouple in concrete cube

Fig. 3. Temperature Measurement Set-up (Digital Thermometer)

D. Casting of Concrete Cubes

The measured amount of cement, fine and coarse total and distinctive weight level of MgAl LDH was blended with water to cast the solid 3D shapes. The readied cement was poured inside the shape, where the 'K-type' thermocouple was at that point fixed. The concrete cubes were casted a role according to the IS code standard. The quantities of concrete cubes threw for the testing reason for existing were 15 numbers with thermocouple for temperature estimation and 45 quantities of concrete cubes for compressive quality test with different weight level of MgAl LDH as latent heat storage and ordinary concrete without the expansion of MgAl LDH.

E. Sample Preparation for XRD Test of Concrete Cubes

Samples were taken for X-ray Diffraction examination from the casted concrete cubes for changing weight rates of MgAl LDH included concrete and normal concrete. Powder from each concrete cubes were gathered by pulverizing the concrete cubes on 30th, 60th and 90th day after water relieving.

F. Sample Preparation for Compressive Strength Test of Concrete cubes

The cast concrete cubes were expelled from the shape following 24 hours and water relieved for 28 days. Compressive quality test was done in a compressive testing machine according to Seems to be: 516:1959 strategy on threw solid 3D shapes on seventh, fourteenth and 28th day for three examples, for each samples of cast concrete cubes.

G. Sample Preparation for Temperature Measurement on concrete cubes

After water relieving the casted concrete cubes for 28 days, cubes set with 'K-type' thermocouples were tried outwardly for breaks or damages on the sample. In the wake of permitting the solid 3D squares for drying and from 30th, 60th and 90th day onwards the temperature was estimated on the concrete cubes utilizing uniquely created digital thermometer appeared in Fig. 3. Concrete cubes were kept in an open revealed place under characteristic encompassing condition and temperature readings were taken for each arrangement of concrete cubes arranged for each bunch and recorded.

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III. Results and Discussion

H. XRD Analysis of Concrete-MgAl

The casted concrete cubes contains with MgAl LDH were tested to understand the role of LDH in the mixture. Concrete powder was collected from the concrete cubes for XRD analysis. The XRD pattern of the cast concrete sample with and without MgAl LDH is appeared in Fig.4. The XRD pattern from the example unmistakably demonstrate the nearness of cement and MgAl LDH, the intensity of diffraction peak increments as MgAl LDH content increased in the concrete. It is clear from the Fig.4. that diffraction peak of concrete in MgAl LDH joined cement marginally moved to bring down esteem contrasted with the ordinary concrete. This perception prompts an end that respectability of MgAl LDH is saved amid the casting of concrete cube and thermodynamically stable amid the casting of concrete cube sample. From XRD design it is apparent that following 30, 60 and 90 days the respectability of the MgAl LDH is protected

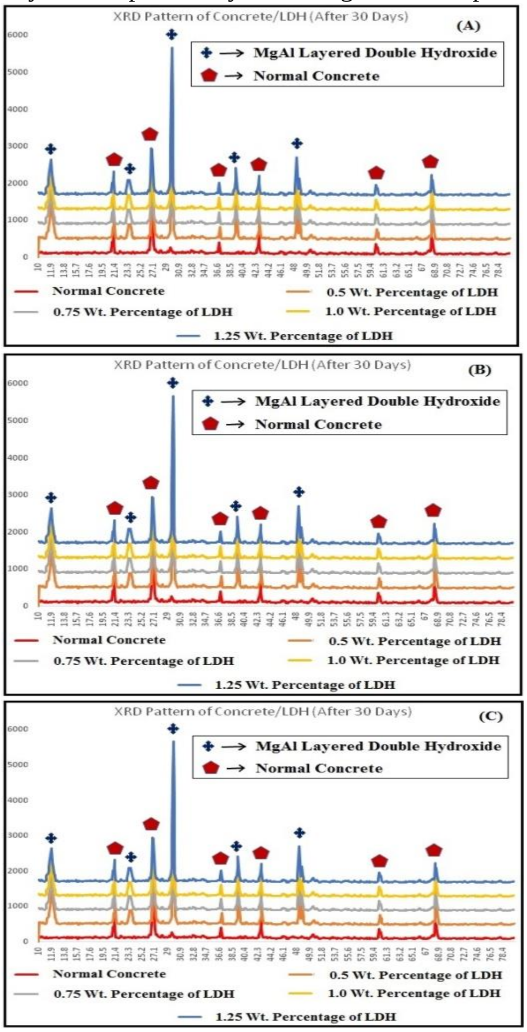


Fig. 4. XRD Pattern of Normal Concrete/MgAl Layered Double Hydroxide

I. Impact of MgAl LDH in Concrete

Fig. (5-9) demonstrates the consequences of the impact of MgAl LDH included cement. From the Fig. (5-9) it is evident that the solid included with fluctuating weight level of MgAl LDH (0, 0.5, 0.75, 1.0 and 1.25 Wt. level of MgAl LDH) and latent heat storage ability of the MgAl LDH was recorded utilizing the indigenous manufactured thermocouple which is appeared in Fig. (5-9). From Fig. (5-9) it is evident that because of the expansion of MgAl LDH, atmospheric temperature consumed by the solid block is put away as an latent heat in the center (focus) and diminishes the temperature on the parallel side of the concrete cubes [28]. The concrete cube included with 1.25 level of MgAl LDH put away most extreme latent heat and reduces the temperature on the horizontal sides up to 3 to 4 degree centigrade which is appeared in the Fig.7. which was estimated after 30th, 60th and 90th day.

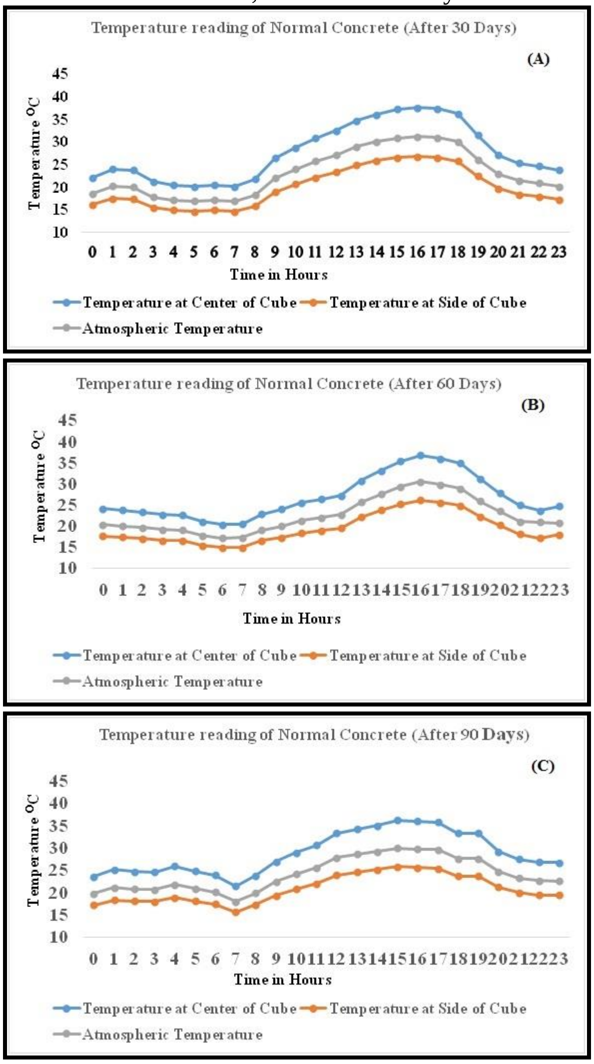
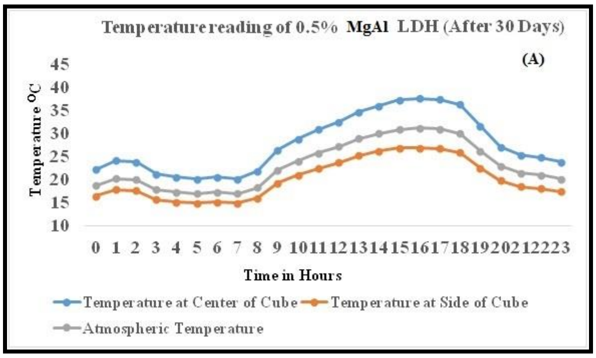


Fig. 5. Temperature Reading on Normal Concrete (A) After 30 Days (B) After 60 Days (C) After 90 Days



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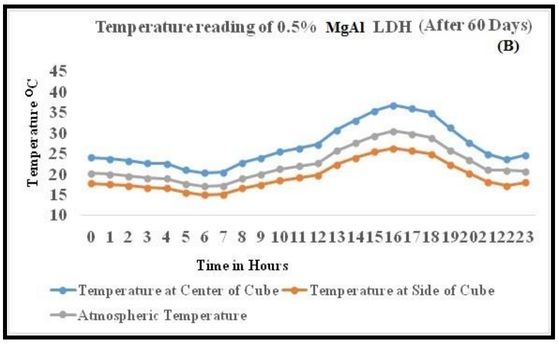


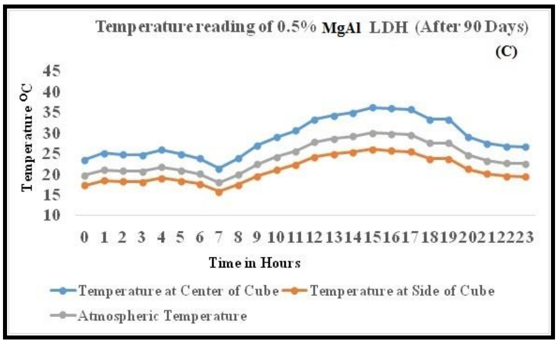
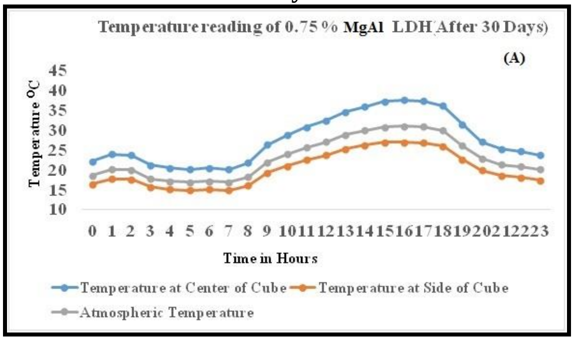
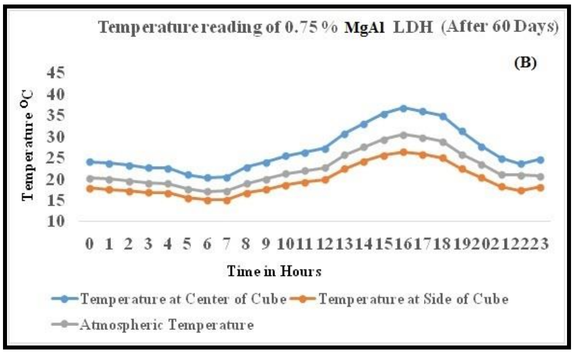


Fig. 6. Temperature Reading on 0.5 Wt.% of (A) Concrete/ MgAl LDH After 30 Days (B) Concrete/ MgAl LDH After 60 Days (C) Concrete/ MgAl LDH After 90 Days





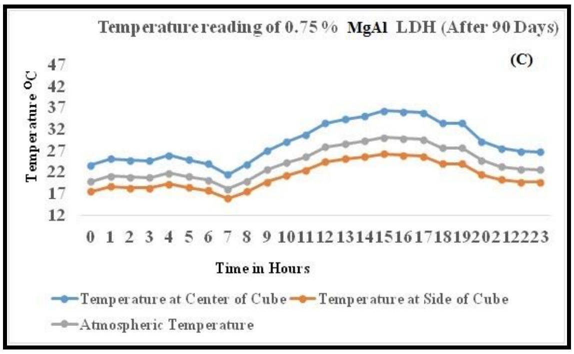
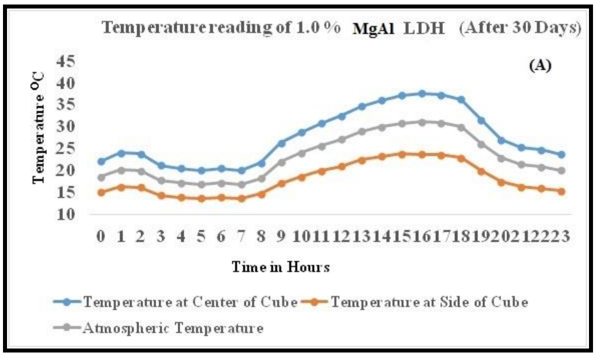
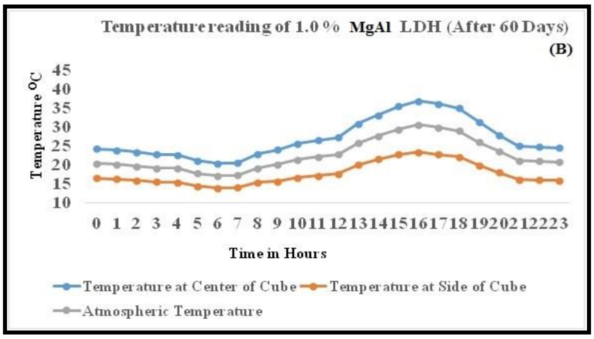


Fig. 7. Temperature Reading on 0.75 Wt.% of (A) Concrete/ MgAl LDH After 30 Days (B) Concrete/ MgAl LDH After 60 Days (C) Concrete/ MgAl LDH After 90 Days





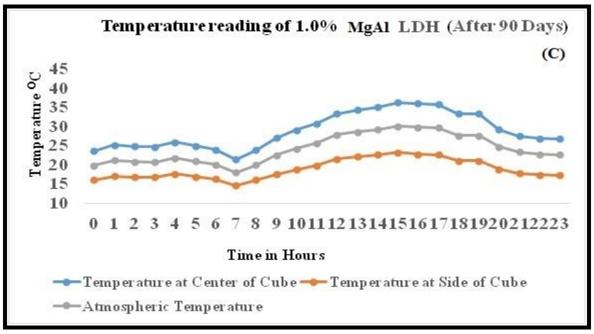
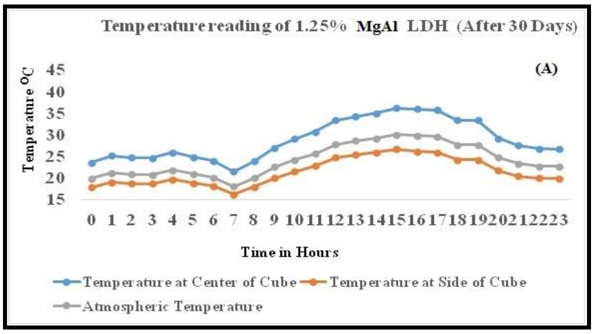
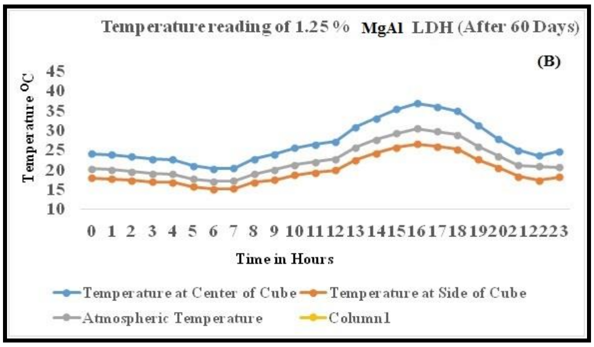


Fig. 8. Temperature Reading on 1.0 Wt.% of (A) Concrete/ MgAl LDH After 30 Days (B) Concrete/ MgAl LDH After 60 Days (C) Concrete/ MgAl LDH After 90 Days





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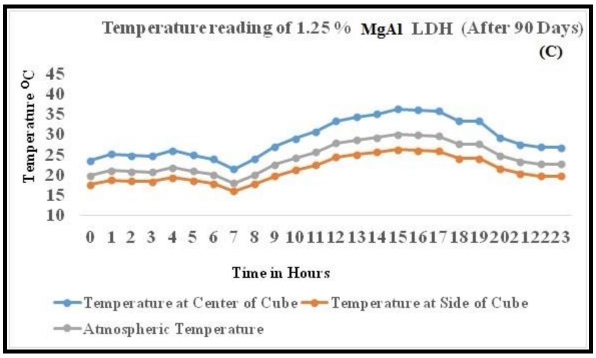

Fig. 9. Temperature Reading on 1.25 Wt.% of (A) Concrete/ MgAl LDH After 30 Days (B) Concrete/ MgAl LDH After 60 Days (C) Concrete/ MgAl LDH After 90 Days

Because of the expansion of MgAl LDH to solid shapes the compressive quality of the solid was not influenced till 1.0 wt.% of MgAl LDH and it is obvious from compressive quality of the solid block which is appeared in Fig.11. The XRD examination of casted concrete/MgAl LDH likewise obviously uncovers the nearness of MgAl LDH and integrity was preserved 30, 60 and 90 days which are appeared in Fig.4. It was uncovered that the impact of cooling has upgraded by the expansion of MgAl LDH to the cast concrete cubes. The MgAl LDH retains the heat and changes over it to latent heat, the changed over latent heat put away in the center or focal point of the concrete and it is apparent from the appeared Fig.(5-9). In Fig. 10. it unmistakably uncovers that 1.0 percentage of expansion of PCM upgrades the cooling impact on side has appeared for the 30th day.

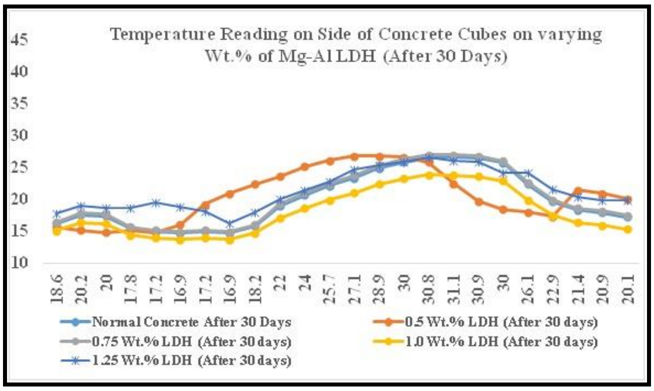

Fig. 10. Comparing the Temperature Reading on Side of Concrete Cubes on varying Wt.% of Concrete/MgAl LDH After 30 Days

J. Compressive Strength of Concrete Cubes

The results of the compressive strength test are shown in Fig.11. A comparative analysis of compressive strength in terms of the percentage of added MgAl LDH is shown in Fig.11. It is apparent from Fig. 11. the compressive strength of the concrete is not affected by the addition of MgAl LDH in different weight percentages when compared with the normal concrete till the weight percentage of 1.0. But it reduces the compressive strength of MgAl LDH added concrete above 1.0 weight percentage when compared with the normal concrete. The compressive strength of the casted concrete cubes was tested on 7th, 14th and 28th day. The compressive strength of the MgAl LDH added concrete cubes gradually increases on 28th day over the normal concrete till 1.0 weight percentage of MgAl LDH.

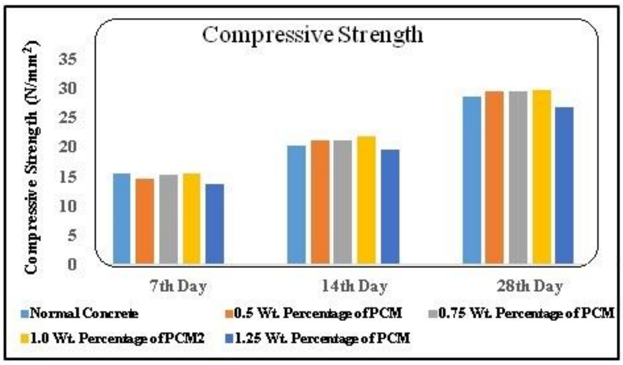

Fig. 11. Effect of Addition on MgAl LDH content to concrete on compressive strength

IV. CONCLUSION

The expansion of MgAl LDH as latent heat storage material with typical M20 review concrete ends up being successful in creating productive warm vitality stockpiling framework in cement and improves the thermal comfort. The trial results with the expansion of MgAl LDH to ordinary concrete by fluctuating weight rate (0.5, 0.75, 1.0 and 1.25 on weight level of concrete), demonstrates that 1.0 wt. level of MgAl LDH added to ordinary cement is powerful away of most extreme inert warmth without influencing the compressive quality of the solid and give great thermal comfort. The nearness of MgAl LDH in cement is additionally affirmed by the XRD design and when the MgAl LDH weight rate builds the pinnacle is likewise somewhat fluctuated. The compressive quality of solid blocks likewise confirm that the expansion of MgAl LDH to concrete does not influence the compressive quality till 1.0 weight rate. Thus 1.0 weight level of MgAl LDH is sufficiently viable to decrease the temperature up to 3 to 4 degrees centigrade in the solid.

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