The Engineering and Economic Feasibility Application of Bioconc on Concrete Quality Treatment in Low Heat Concrete

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ABSTRACT

This paper discuss the concrete hydration thermal control with the economical and eco-friendly Method Statement, based on the basic performance of concrete bio-admixture, Bioconc, which is produce micro-filler, reduce the binder content up to 40%. The concrete hydration thermal sources is from the cement as binder, since Bioconc may reduce up to 40% binder content, the concrete hydration thermal can be controlled and worked as Low Heat Concrete. The paper limited discuss about the application of the Bioconc, for laboratory scale trial mix, Low Heat Concrete mock up modelling test and comparison with another 2 (two) Low Heat Concrete above mentioned [1], [4] and does not discuss the Bioconc ingredient.

The research started by laboratory scale trial mix Fc'25 Low Heat Concrete Bioconc based concrete Job Mix, from cement content reduction 20%, 25%, 30% and 40%. The attached result shows optimum joinmix is Fc'25 Low Heat Concrete Bioconc based concrete Job Mix on 40% cement as binder content reduction, was chosen as Low Heat Concrete Mix Mock Up. Later on, further research make mock up for sampling mass concrete dimension 1000x1000x2500 mm³ was executed. The attached Graph Thermal Monitoring Low Heat Concrete shows that the peak temperature occurred 63.5°C in 29.5 hours after pouring and maximum thermal differential between LHC layers is 19.5°C. Another two Low Heat Concrete Method Statement, i.e.: Pre-cooling and Low Heat Concrete with Fly Ash 40%, Mock Up Graph Thermal Monitoring also attached for comparison study. The observation and analysis proof that, “Low Heat Concrete Hydration Thermal Reduction with Bioconc” is work simplifier and economically, for mass pouring. The most essential thing is that, the basic concept of Bioconc’s Low Heat Concrete on reducing the mass concrete cement-binder content means reducing CO₂ emission in every concrete production, without any hazard impact to the environment. Its mean Bioconc based Low Heat Concrete contribute to develop the green technology and eco-friendly technology on the concrete industry as sustainable green technology.

Keywords: Mass Concrete, Concrete Hydration Thermal Control, Low Heat Concrete, Pre-Cooling, Post Cooling, Bioconc, Green Technology, Eco-Friendly

I. INTRODUCTION

Concrete is most common construction material which is use on every construction project. Mostly concrete construction material, especially related to highrise building structural elements, in large dimension forms mass concrete. Mass concrete is any volume of concrete with dimension large enough to require that measures be taken to cope with the generation of heat from hydration of cement and attendant volume change to minimize cracking. The design of mass concrete structure is generally based on durability, economy, and concrete hydration thermal control, and strength often being secondary concern. [1]

Therefore this journal is written the research on how to control the hydration thermal control with Bioconc, in concentration of discussion to observe the engineering feasibility and economical feasibility.

1.1. Research’s Object
The Object of Research is how to control concrete thermal hydration on mass concrete with bio-admixtures Bioconc, compared with existing command method statement in control mass concrete thermal hydration, on precooling as described previously on reference [1] and [4]. One of Bioconc component produce microfiller insert the microgap of the concrete aggregate composite which is usually filled cement binder, so the cement content will be reduced and the composite aggregate surface binded increase, this increasement proofed related to the strength increasement on next research data result. Following pictures shown the comparison of Scan Electronic Microscopy (SEM) of Bioconc treated concrete (Photo-1) and normal concrete (Photo-2).

1.2. The Aim of Research

The Research's Aim is directed to observe the following objects:
1.2.1. The engineering effectiveness of concrete bio-admixture, Bioconc on control the concrete thermal hydration, compared with another mass concrete hydration thermal control as reference [1] and [4].
1.2.2. The effectiveness of concrete bio-admixture, Bioconc on increase the mass concrete quality, compared with another mass concrete hydration thermal control as reference [1] and [4].
1.2.3. The economical effectiveness of the application of concrete bio-admixture, Bioconc on control the concrete thermal hydration on Low Heat Mass Concrete compared with another mass concrete hydration thermal control as reference [1] and [4].

1.3. Scope of Discussion and Discussion Limit

The discussion scope is directed on the following object:
1.3.1. Laboratory scale trial mix, directed to observe the optimum Bioconc ‘e Low Heat Concrete Jobmix.
1.3.2. The mass concrete modelling or mock up scale of Bioconc based, Low Heat Concrete 1000x1000x2500 mm3 dimension, observation to discover the peak temperature on peak time.
1.3.3. Simply economical calculation of the Bioconc based, Low Heat Concrete application.

Those scope of discussion are compared with another mass concrete hydration thermal control reference [1] and [4].

This journal will not discuss the following objects:
- Bio-admixtures ingredients
- Bio-chemical process on bio-admixture works in concrete quality treatment
- All related to the production-line

II. METHOD STATEMENT
The bio-admixture Bioconc treatment concrete job mix modification from original job mix (non fly ash job mix) is described on the following table-1:

| Observed cement content (binder content) reduction | R % |
| Concrete Job Mix - Grade (G) | Fc'25 (in this research, but not limited to) |
| Concrete Volume - standard jobmix reference | 1 m³ |
| Optimum Bioconc dosage in 1 m³ of Concrete | 600 cc. [10] |

Table-1 : NFA Job Mix and Bioconc Jobmix Modification

| Material Mix | NFA Mix | Bioconc Jobmix Modification |
|--------------|---------|-----------------------------|
| Cement       | A       | A . (1 - R%)                |
| Water        | B       | B . (1 - R%)                |
| Coarse Ag-1  | C       | C+ (A+B).R%.{C/[C+D+E]}    |
| Coarse Ag-2  | D       | D+(A+B).R%.{D/[C+D+E]}     |
| Fine Agreggt | E       | E+(A+B).R%.{E/[C+D+E]}     |
| Bioconc (cc) | -       | 600 cc                      |
| Total Weight | A+B+C+D+E | A+B+C+D+E+600cc             |

The sequence of the research executes as the following method statement, refer to the previous research on reference [8], [9], [10], describe on the following flow chart:
Figure-3 : Flow Chart of Research Method Sequence

1. NFA-Mix Fc'25 (Non Fly Ash/Standard Mix)
2. Fc'25 + 20%FA Mix + Ice (4 Pcs Ice Block) [1]
3. Fc'25 + 40%FA Mix (Low Heat Concrete-LHC) [4]
4. Fc'25 + Bioconc (600cc/m3 Concrete) - R20%
5. Fc'25 + Bioconc (600cc/m3 Concrete) - R25%
6. Fc'25 + Bioconc (600cc/m3 Concrete) - R30%
7. Fc'25 + Bioconc (600cc/m3 Concrete) - R40%
Figure-4 : Strength Test of Cylindrical Samples Lab Trial & Site Mock Up Mass Concrete
**Optimum Jobmix**

- LHC.Fc’25+FA40%
  - Fc’ 25 Mpa
  - Fly Ash 40%
  - Slump 12 ± 2 cm
  - Additive (SP and Retarder 0,5%)
  - Mock Up LHC 1000x1000x2500 mm³

- Concrete FC’25+FA20
  +4pcs Ice Block/m³
  - Fc’ 25 Mpa
  - Fly Ash 20%
  - Slump 12 ± 2 cm
  - Additive Retarder 0.5%
  - Mock Up LHC 1000x1000x2500 mm³

- Bioconcrete LHC.Fc25
  R=40%
  - Fc’ 25 Mpa
  - Cement R=40%
  - Slump 12 ± 2 cm
  - Additive (Normed R.60 = 0.5%)
  - Mock Up LHC 1000x1000x2500 mm³

**Cylinder Sampling**

- Concrete LHC FA 40%
  - Sampling Test 3 d
  - Sampling Test 7 d
  - Sampling Test 14d
  - Sampling Test 28d
  - Sampling Test 3 d
  - Mock Up Thermocouple monitoring every 30 minutes to obtain:
    - Peak temperature
    - Time on reaching Peak temperature

- Concrete FA.20%
  - 4pcs Ice Block
  - Sampling Test 3 d
  - Sampling Test 7 d
  - Sampling Test 14d
  - Sampling Test 28d
  - Sampling Test 3 d
  - Mock Up Thermocouple monitoring every 30 minutes to obtain:
    - Peak temperature
    - Time on reaching Peak temperature

- Bioconcrete LHC
  - Cement Reduction 40%
  - Sampling Test 3 d
  - Sampling Test 7 d
  - Sampling Test 14d
  - Sampling Test 28d
  - Sampling Test 3 d
  - Mock Up Thermocouple monitoring every 30 minutes to obtain:
    - Peak temperature
    - Time on reaching Peak temperature

**Thermocouple Result**

- Engineering Discussion

- Economical Analysis & Comparison

- Conclusion & Advice

**Figure-5**: Sequence of Mass Concrete Hydration Thermal Control Research
III. RESULT

Based on the above mentioned sequences method of research, the following output data found:

3.1. Bioconc Low Heat Concrete $F_c'25$, with Cement Binder Content Reduction $R=40\%$ Research Data Result

The Mock Up Bioconc Treatment Low Heat Concrete with cement binder content reduction $R=40\%$ to control concrete hydration thermal, on mass concrete modelling 1000x1000x2500 mm$^3$, Graph thermocouple monitoring output data, figured on the following graph (Picture-3):

![Graph Monitoring Temperature Bioconc Treatment Low Heat Concrete](image)

![Table: Low Heat Concrete - Bioconc Based Performance as Microfiller on $R=40\%$](table)

![Figure-6: Thermocouple Bioconc-LHC Monitoring, Summary Data & Mock Up Sketch](image)

3.2. $Fc'25$ +Concrete Fly-Ash $20\%$ + 4 pcs Ice Block/m$^3$ Concrete Research Data Result
The Mock Up of Fc’25+FA20%+4pcs Ice Block to control concrete hydration heat, on mass concrete modelling 1000x1000x2500 mm3, Graph thermocouple monitoring output data, figured on the following graph (Picture-4):
Figure -8 : Thermocouple Fc'25+FA40%+LHC Graph Monitoring , Summary Data & Mock Up Sketch

IV. DISCUSSION
Mainly concern of mass concrete Quality Control is on the Hydration Thermal Control, as the above mentioned research data result (item 3.1, 3.2 and 3.3) can be summarized as following table :

| Material Mix | Bioconc LHC | FA20%+Ice | LHC-FA40% |
|--------------|-------------|-----------|-----------|
| Peak Thermal | 63.5 ° C    | 62.6 ° C  | 68.8 ° C  |
| Peak Time    | 29.5 hours  | 71 hours  | 60 hours  |
| Dif. Thermal | 19.7 ° C    | 7.9 ° C   | 8.9 ° C   |

Based on Table-2, Bioconc Treatment Low Heat Concrete the faster method to reach the peak time on 29.5 hours from concrete pouring. On construction process, its mean cost advantage, since faster the peak temperature of mass concrete occured, faster the next step of construction can be execute, also cheaper over head cost in maintaining the mass concrete, such as rent of mass concrete tends, curing, etc.

Secondly concern of mass concrete Quality Control is on the concrete strength is the concrete cylindrical samples strength test as describe on Figure-4, shown that varioust Concrete Strength Tests are match to the specified.

5. Economical Feasibility Analysis
Based on the each jobmix material proportion, Low Heat Concrete LHC-$F'c_{25}+FA40\%$, $F'c_{25}+FA20\%+Ice$ block and Bioconc Treatment Low Heat Concrete with cement binder content reduction $R=40\%$, can be analysed the initial each cost of production as the following table-3:

| No. | Material Composition | Cost of LHC FA 40% | Cost of LHC FA 20% + Ice Block | Cost Of LHC Bioconc | Remark |
|-----|----------------------|-------------------|-------------------------------|-------------------|--------|
| 1   | Cement               | 236.0             | 315.0                         | 236.0             |        |
| 2   | Water                | 158.0             | 158.0                         | 100               |        |
| 3   | Fly Ash              | 158.0             | 79.0                          | 100               |        |
| 4   | Coarse Agg           | 1,160.0           | 1,160.0                       | 250               |        |
| 5   | Fine Agg             | 760.0             | 760.0                         | 175               |        |
| 6   | Ice Block            | -                 | 35,000                        | 0                 |        |
| 7   | Ice Block Storages   | 1.0               | 52,500                        | 52,500            |        |
| 8   | Bioconc              | -                 | 60,000                        | -                 |        |

| Total Initial Cost of Production | 690,600 | 954,200 | 722,800 |

Table-3: Initial Cost Of Production Analysis and Comparison

Based on Table-3, $F'c_{25}$-LHC+FA40\% is the cheapest one, but considering the risk of environmental hazard and human health\(^6\) the Bioconc Treatment Low Heat Concrete as the mass concrete's hydration thermal control is the wise option to avoid any environmental hazard and human health.

VI. CONCLUSION

6.1. Considering the eco-friendly, engineering and economical aspect, the Bioconc Treatment Low Heat Concrete satisfy all related condition.
6.2. Considering the time required to reach peak temperature, the Bioconc Treatment Low Heat Concrete fastest method to control mass concrete's hydration thermal in 29.5 hours after pouring. This faces impact to reduce indirect cost of production of the mass concrete, and speed up to execute the next stage of construction.

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