International Journal of Engineering Research And Management (IJERM)
ISSN : 2349- 2058, Volume-03, Issue-05, May 2016

Effect of Fly Ash as Supplementary Materialin Portland Pozzolana Cement Concrete

Anoop Banwala, Dr. Arvind Dewangan, Er. Bhavana Arora

***Abstract*— The era of infrastructure increased in recent year, so the advancement of concrete technology exaggerated day by day in life. Use of concrete exaggerated the consumption of natural resources and energy sources. In recent years inordinate measure of fly ash generated in thermal industries. The previous couple of years, some cement firms have started mistreatment ash in producing cement called hydraulic cement, however, the utilization of ash remains terribly low. There's intolerably opportunity for the fly ash in cement likewise as in concrete.This work describes the use of Non-conventional artifact (Fly ash) that is definitely out there. During this work cement and fine aggregate has been partly replaced by fly ash consequently within the range of 0% (without fly ash), 10%, 20%, 30%, 40% and 60% by weight of cement for M-25 Mix Concrete mixtures were moulded, tested and compared in terms of compressive and split strength.**

***Index Terms*— Concrete, Compressive Strength, Admixture, Productivity**
Area : Construction Technology & Management

I. INTRODUCTION

Portland cement is an essential component of concrete, and India currently produces about 100 million tons of this material annually; the manufacturing of Portland cement in India directly results in the emission of over 80 million tons of CO2 annually. Without the introduction of new technologies and practices to use larger proportions of supplementary cementing materials (SCMs) such as fly ash, either directly in concrete production, or through the increased use of blended cements incorporating significant percentages of SCMs, the production of ordinary Portland cement will increase significantly in India to meet the rapidly increasing demand from the concrete industry. Consequently, this would translate into a significant increase of CO2 emissions. Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. These industrial wastes are dumped in the nearby land and the natural fertility of the soil is spoiled. Fly ash is the finely divided mineral residue resulting from the computation of ground or powdered coal in electric power generating thermal plant. Fly ash is a beneficial a mineral admixture for concrete. It influences many properties of concrete in both fresh and hardened state. Moreover, utilization of waste materials in cement and concrete industry reduces the environmental problems of power plants and decreases electricity generation costs. Cement with fly ash reduces the permeability of concrete and dense calcium silicate hydrate (C-S-H). Research shows that adding fly ash to concrete, as a partial replacement of cement (less than 35%), will benefit both the fresh and hardened states. While in the fresh state, the fly ash improves workability. This is due to the smooth, spherical shape of the fly ash particle. The tiny spheres act as a form of ball bearing that aids the flow of the concrete. This improved workability allows for lower water-to-cement ratios, which later leads to higher compressive strengths.

Manuscript received June 04, 2016

Anoop Banwala, M.Tech. Final Semester, Construction Technology & Management (Civil Engg.), HCTM Technical Campus, Kathal-Haryana
Dr. Arvind Dewangan, Prof & HOD, Civil Engineering Department, HCTM Technical Campus, Kathal-Haryana
Er. Bhavana Arora, Asstt. Prof. - Civil Engineering Department, HCTM Technical Campus, Kathal-Haryana

II. OBJECTIVE

The study has been carried out with the following objective:

1. To study suitability of fly ash as cement replacement in Portland Pozzolana Cement (PPC) concrete with the view to compressive strength.
2. To study suitability of fly ash as fine aggregate replacement in Portland Pozzolana Cement (PPC) concrete with the view to compressive strength.
3. To study suitability of fly ash as cement replacement in Portland Pozzolana Cement (PPC) concrete with the view to tensile strength.
4. Cost analysis.

III. LITERATURE REVIEW

Fly ash that meets the strength requirement of grades M20, M25 and upto M60 concrete' such concrete will develop acceptable early age's strength, higher strength at later ages, and significantly lower chloride-ion penetrability compared to control concretes of similar grade made with OPC only.

The compressive strength development and corrosion-resisting characteristics of concrete mixes in which fly ash was used as an admixture (equal quantity of sand replacement). Concrete mixtures were made with fly ash additions of 0%, 20%, and 30%, and water-cement ratios of 0.35, 0.40, 0.45, and 0.50. Based on the test results, they concluded that addition of fly ash as an admixture increases the early age compressive strength and long-term corrosion-resisting characteristics of concrete. The superior performance of these mixes compared to plain concrete mixes was attributed to the densification of the paste structure due to pozzolanic action between the fly ash and the calcium hydroxide liberated as a result of hydration of cement.

IV. RESEARCH METHODOLOGY

In the previous chapter Literature review and gap had been discussed. On the basis of literature survey and objectives a suitable method is required for Precast Concrete System in this study. There are several statistical techniques available in research methodology, from them, Method Productivity Data Model (MPDM) and Construction Production Data Model (CPDM) has been used in this theoretical evolution for Precast Concrete Systems in which data may be collected and analyzed by statistical methods resulting in valid or, required intentions. The methodology followed during this research work is given in figure 3.1.

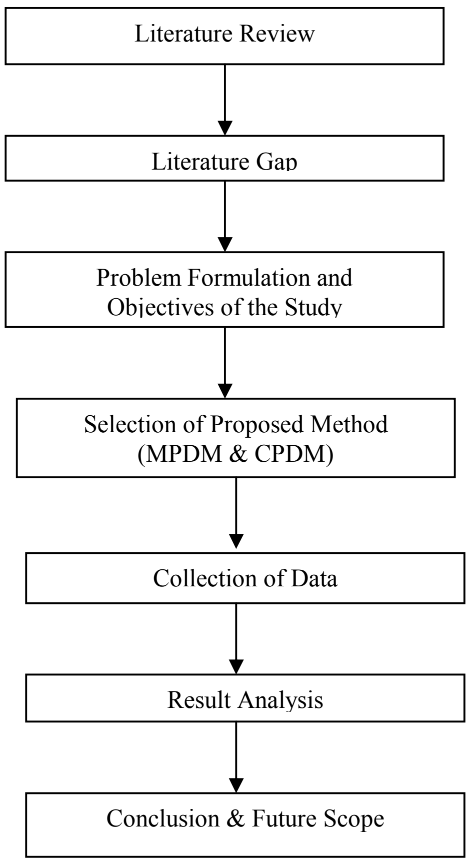

Figure : Research Methodology

V. METHOD PRODUCTIVITY DELAY MODEL

The Method Productivity Delay Model (MPDM) is a model to measure, predict, and improve productivity. The model was developed by Dr. James Adrian and it is broken down into three elements: collection of data, model processing and structuring, and implementation (Adrian, 2004). Data is collected on three items – the production unit, the production cycle, & the time required for completion of production cycles as well as productivity delays (Adrian, 2004). The production cycle time is documented by noting the time between completions of production units. The types of delays that are usually documented are environment, equipment, labor, material, & management. The processing of MPDM consists of the operations of measuring ideal productivity & overall productivity. Ideal productivity occurs when there are no productivity delays. The environmental, equipment, labor, material, & management factors in the productivity equation (Equation 7) relate the ideal productivity to the overall productivity (Adrian, 2004). Of the three elements of the MPDM process, the most important is the implementation of the model. The inspection of the MPDM structure can inform the contractor of the critical delays resulting in a high percentage of production delay times. The contractor can then focus on these critical delays while attempting to improve productivity.

The basic concept of MPDM is that simplified measures will make the method more accessible to relatively low-level field personnel (Halpin & Riggs, 1992). As MPDM is a simple method for calculating productivity factors, there are less chances of error, and results can be more trustworthy. On the other hand, the method is very limited and of questionable value when applied to extremely short-cycle or relatively long-cycle processes. This occurs because of value judgements that must be made by the data collector. These subjective judgments tend to undermine the objectivity of the data and impact the reliability of the results obtained (Halpin & Riggs, 1992).

VI. CONSTRUCTION PRODUCTION DATA MODEL

Many studies or methodologies directed at analysing delay and lost productivity have been reported (Kallo 1996; Bubshait and Cunningham 1998; Al-Saggaf 1998; Kartam 1999; Finke 1999; Reichard and Norwood 2001).The problems of delay calculating studies related to lost productivity can be summarized as three cases as follows. (1) Established calculating studies of delay related to lost productivity, which are limited to studies of converting lost productivity into cost using such as measured mile analysis and the productivity data published from CII, NECA and MCAA. (2) Delay causes are conceived as activity in a project schedule such as a method of "What-If" evaluation, "But-For" schedules, "affected baseline schedule" and "collapsed as-built analysis". (3) The impacted activities are analyzed in the form of activities that have non-impacted productivity. However, if some variables or impact factors impact the next work in the sequence, the impacted work must be lost productivity work. As a result, a study concerning methods of calculating schedule delay considering lost productivity is not sufficient.

VII. BASIC CONCEPTS

Productivity may be defined as the quantity of work produced per man-hour, equipment hour, or crew hour (Finke 1998).As shown in Figure 1, it can be said that the lost productivity is the productivity impacted adversely by unexpected factors or impact factors. For example, a curtain wall crew consisted of 5 workers installing 34.65m2 per hour can be said to have a productivity rate of 6.93 m^2/hour under good conditions not influenced by any other impact factor. But if a work affected by any impact factor such as unexpected adverse weather, it will take some times or days for the impacted work productivity to be the un-impacted work productivity or the planned work productivity. The work productivity will be declined.

To calculate fairly the delay of the liquidated damage, it is needed a calculating method related to many impact factors and their impacted productivity. The following concepts were employed:

1. Planned Work Duration (PWD) is the work duration with the planned productivity.
2. Actual Work Duration (AWD) is the work duration with the actually un-impacted productivity obtained from the entire period of work duration.
3. Start Time Variance (STV) is the difference between the actual start time of a work and the finish time of the preceding work on an as-built schedule
4. Finish Time Variance (FTV) is the difference between the contractor's AWD and PWD.
5. Lost Productivity Quantity (LPQ) denotes the work quantity, which could be finished during un-impacted work duration.
6. Lost Productivity Duration (LPD) can be defined as opportunity duration could be worked as much as LPQ.

The Variables used in Equations

Work Status	Work Quality	Work Productivity	Daily Average Labors	Work Duration
Planned Work	Q_0	P_0	L_0	D_0
Work of Un-impacted Duration	Q_u	P_u	L_u	D_u
Work of Impacted Duration	Q_i	P_i	L_i	D_i

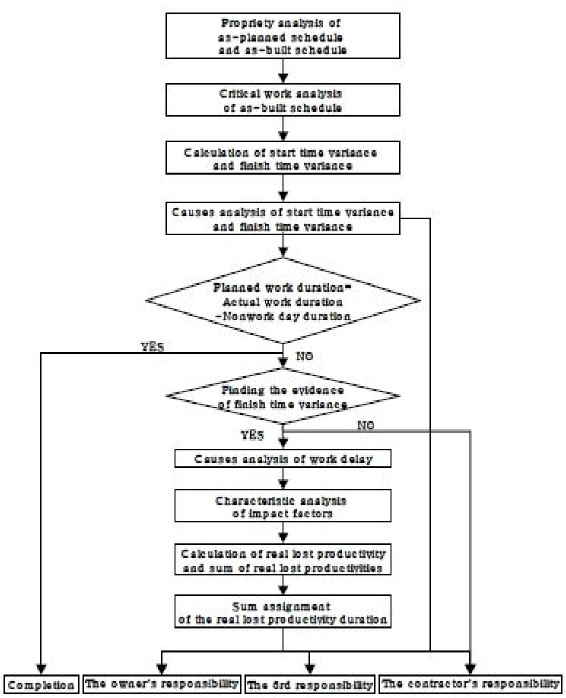

Figure : The calculation process of Delay Duration

The LP of some activity can be calculated like Eq. (1) by the difference between the un-impacted productivity of the activity and the impacted productivity of the activity. The LPQ can be calculated like Eq.(2) by LP multiplied by Li(worked labours) during Di(impacted work duration). The LPD can be calculated like Eq.(3) by LPQ divided by the product of daily average labours during impacted work duration and un-impacted productivity. The variables are in Table .

$LP = (P_u – P_i)$ Eq. (1)
$LPQ = (P_u – P_i)\times L_i\times D_i$ Eq. (2)
$LPD = LPQ/L_iP_u = (P_u – P_i)\times L_i\times D_i/L_iP_u$ Eq. (3)

Could Be Duration (CBD) denotes the duration within which a work could be finished with the daily average labours and the un-impacted productivity; This can be calculated by Eq.(4), where Q_0 denotes the planned work quantity, Q_u denotes the quantity worked in the normal and realistic work conditions of an un-impacted work duration, and Q_i denotes the quantities worked in the impacted work duration.

$CBD = Q_0/ L_uP_u = (Q_u + Q_i)/ L_uP_u$ Eq. (4)

Contractor's Duration Difference (CDD) compared with the P_0 and the P_u denotes the difference CBD and D_0 by Eq.(5), where P_0 denotes the planned work productivity and D_0 denotes the planned work duration.

$CDD = CBD- D_0 = (Q_0/ L_uP_u) – D_0$ Eq. (5)

Work Delay (WD) consists of CDD, LPD and ∀ as shown in Eq.(6), where CDD and LPD are independent variables and ε is an extraneous variable that accounts for any delays other than CDD and LPD.

$WD = CDD + LPD + \varepsilon$ Eq. (6)

Statically Analysis

Production Cycles	**A**
Non-Delay Cycles	B
Mean Non-Delay Cycles	C
Overall production Cycles **Cycle Time-Delay Cycle Time/n**	D
Non-Delay Cycles **Cycle Time-Delay Cycle Time/n**	E

There are four types of information involved in the model. The first is called the variability of the method productivity, i.e., ideal cycle and overall cycle variability which provide a measure of the variable nature of the process according to the two following equations:

$$\text{Ideal Cycle Variability} = \frac{\text{Variation measure or Row A of table 3.1}}{\text{Mean non delay cycletime}}$$

$$\text{Overall Cycle Variability} = \frac{\text{Variation measure or Row B of table 3.1}}{\text{Mean overall cycletime}}$$

The above two equations are applied by dividing the last column of rows A and B of Table 4.2 by the next-to- last column of rows A and B, respectively.

VIII. Modal Results

Table (4.3) depicts the relative impact of delay causes on productivity. Material, equipment availability and Row (E) of Table (4.3) is the relative frequency probability of occurrence for each delay type, i.e., occurrence of delayed cycles due to environment divided by the sum of occurrences (sum of row C).

CONCLUSION

From the above study following conclusions are drawn:
Compressive Strength (when cement replaced with fly ash)

1. The compressive strength of fly ash concrete up to 30% replacement levelis slightly equal to referral concrete at 28 and 56 days.
2. Optimum replacement level of fly ash is 20%, at 20% replacement levelincrease in strength at 28 and 56 days is 1.9% & 3.2%.

Compressive strength (when fine aggregate replaced with fly ash)

3. The compressive strength of fly ash concrete at 50% replacement level increased in strength with referral concrete is 15.4% and 18% at 28 & 56 days.

Splitting tensile test (when cement replaced with fly ash)

4. The split tensile strength of fly ash concrete up to 20% replacement levelis more than referral concrete at 7, 28 and 56 days.
5. Optimum replacement level of fly ash is 20%
6. At 20% replacement level increase in tensile strength at 7, 28 and 56 daysis 13%, 5.63% and 19.0%.

Cost analysis

7. By using Fly ash at 30% in concrete as cement replacement material, thematerial cost may decrease up to 23.34%.
8. It is observed that in PPC gains final strength after the 56 days curing.
9. Increase in strength after 56 days curing showed because of slow hydration process of Fly Ash PPC concrete. Since Fly ash is a slow reactive Pozzolanic material.
10. The scope of research documented herein covers the onsite installation activities by using MDPM and CPDM methods. Although, the pre-cast concrete plant production impacts the installation Productivity however, productivity improvements at the plant level is left for future work. The analysis can be performed in this research for material unavailability, equipment unavailability and management errors (as per Table) and major delay cause via the MPDM analysis can be realized for the pre-cast plant. After applying the previous discussed methodologies, the outcomes of the requirements could be realize.

IX. REFERENCES

[1] Alhassan A. Y. ApataA.O..(2012) “The Behaviour of Portland – Pozzolana Cement Concrete in Aggressive Environments”.Journal of Emerging Trends in Engineering and Applied Sciences. (ISSN:2141-7016). (JETEAS) 3 (4): 2012 pp. 673-676. Jeteas.scholarlinkresearch.org. © Scholarlink Research Institute Journals.

[2] Alam J., Akhtar M.N., (2011) “Fly ash utilization in different sectors in Indian Scenario”.International journal of emerging trends in Engineering and Development. Issue 1, Vol 1 August.

[3] Bakoshi T., Kahno K., Kawasaki S., Yamaji N., (1998) “Strength and durability of concrete using bottom ash as replacement for fine aggregate,” ACI Spec. Publ. (SP-179) 159-172.011.

[4] Badur S. Choudhary R, (2008) “Utilization of hazardous wastes and By-products as a green concrete material through s/s process: a review,” Advanced Study Center Co. Ltd.Rev.Adv.Master.Sci.17, 24-61