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Significance of Precast Concrete System

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***Abstract*— The concept of precast (also known as "prefabricated") construction includes those buildings, where the majority of structural components are standardized and produced in plants in a location away from the building, and then transported to the site for assembly. These components are manufactured by industrial methods based on mass production in order to build a large number of buildings in a short time at low cost.**

Index Terms— Precast, Construction, MPDM, Productivity
Sub Area : Construction technology & Mgmt.
Broad Area : Civil Engineering

I. INTRODUCTION

In this work, Pozzolana Portland Cement (PPC) of prism brand obtained from single batches throughout the investigation was used. The Portland cement content mainly two basic ingredients namely argillaceous and calcareous. The physical properties of PPC as determined are given in table 3.1. The cement satisfies the requirement of IS: 1489:1991.

Table – 3.1 Properties of Cement

S.No.	Properties	Experimental	Codal requirement (IS 1489 (Pt-1)-1991)
1	Normal consistency%	31.5%	
2	Initial setting time	157 minute	(Not less than 30 minute)
3	Final setting time	223 minute	(Not more than 600 minute)
4	Fineness of cement (Le-chatelier expansion)	0.65mm	(Not more than 10 mm)
5	Fineness of cement (%age retained on 90 micron IS sieve)	3.45%	10%
6	Specific gravity of cement	2.67	3.15
Compressive Strength			
7	3 Days	17.8 N/mm^2	16.0N/mm^2 (minimum)
8	7 Das	22.5 N/mm^2	22N/mm^2 (minimum)
9	28 Days	33.5 N/mm^2	33N/mm^2
10	Declared % of Fly ash	26.0	10.0-25.0 (min-max) The homogeneity of the mixture shall be guaranteed Written

II. FINE AGGREGATE

The fine aggregate was locally available river sand which is passed through 4.75mm
sieve. The specific gravity of fine aggregate is 2.3 and fineness modulus of fine aggregate is 2.524 Result of sieve analysis is given in Table 3.2

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Table – 3.2 Result of sieve analysis

S.No.	Sieve Size	Weight Retained (gm)	Weight Retained (%)	Weight Passing (%)	Cummulative weight % passing
1	4.75 mm	52	5.2	94.8	5.2
2	2.36 mm	30	3.0	91.8	8.2
3	1.18 mm	110	11.0	80.8	19.2
4	600 µ	100	10.0	70.8	29.2
5	300 µ	346	34.6	36.2	63.8
6	150 µ	330	33.0	3.2	96.8
7	Pan	32	3.2	0	100
					Total=252.4

Fineness Modulus = 252.4/100 = 2.52

III. COARSE AGGREGATE

The coarse aggregate was locally available quarry having two different sizes, one fraction is passing through 20mm sieve and another fraction passing through 10mm
sieve. The specific gravity of coarse aggregate is 2.66 for both fractions. The grading ofcoarse aggregate of 10mm and 20mm size are given in Table. Proportion of 20mm and 10mm size aggregate was taken as 65% and 35%.
The main features of this construction process are as follows:

- The division and specialization of the human workforce
- The use of tools, machinery, and other equipment, usually automated, in the production of standard, interchangeable parts and products.
- Compared to site-cast concrete, precast concrete erection is faster and less affected by adverse weather conditions.
- Plant casting allows increased efficiency, high quality control and greater control on finishes.

This type of construction requires a restructuring of entire conventional construction process to enable interaction between design phase and production planning in order to improve and speed up construction.

1.1 Types of Precast Systems

Depending on the load-bearing structure, precast systems can be divided into the following categories:

- Large-panel systems
- Frame systems
- Slab-column systems with walls
- Mixed systems

Large Panel Systems

The designation "large-panel system" refers to multi-storey structures composed of large wall and floor concrete panels connected in the vertical and horizontal directions so that the wall panels enclose appropriate spaces for the rooms within a building. These panels form a box-like structure. Both vertical and horizontal panels resist gravity load. Wall panels are usually one story high. Horizontal floor and roof panels span either as one-way or two-way slabs. When properly joined together, these horizontal elements act as diaphragms that transfer the lateral loads to the walls.
Depending on wall layout, there are three basic configurations of large-panel buildings:

- Cross-wall systems
- Longitudinal wall systems
- Two-way systems

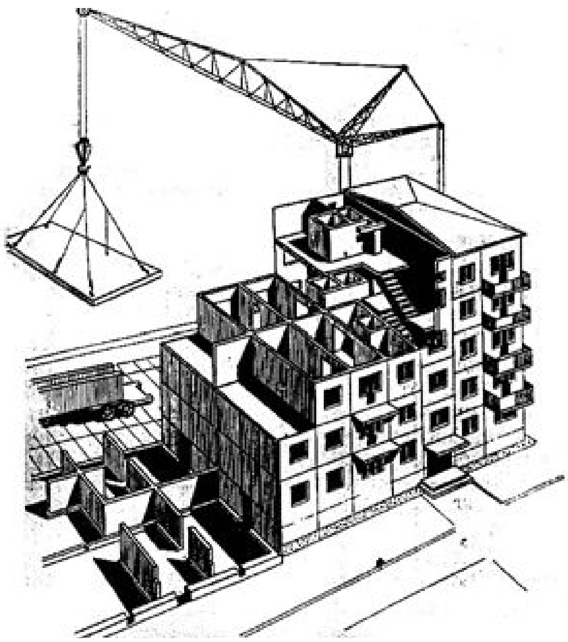


Figure 1.1 A large-panel concrete building under construction

Depending on the wall layout, there are three basic configurations of large-panel buildings:

- Cross-wall system. The main walls that resist gravity and lateral loads are placed in the short direction of the building.
- Longitudinal-wall system. The walls resisting gravity and lateral loads are placed in the longitudinal section; usually, there is only one longitudinal wall, except for the system with two longitudinal walls developed in Kazakhstan (WHE Report 32).
- Two-way system. The walls are placed in both directions (Romania, WHE Report 83).

Frame Systems

Precast frames can be constructed using either linear elements or spatial beam column sub-assemblages. Precast beam-column sub-assemblages have the advantage that the connecting faces between the sub-assemblages can be placed away from the critical frame regions; however, linear elements are generally preferred because of the difficulties associated with forming, handling, and erecting spatial elements. The use of linear elements generally means placing the connecting faces at the beam-column junctions. The beams can be seated on corbels at the columns, for ease of construction and to aid the shear transfer from the beam to the column. The beam-column joints accomplished in this way are hinged. However, rigid beam-column connections are used in some cases, when the continuity of longitudinal reinforcement through the beam-column joint needs to be ensured. The components of a precast reinforced concrete frame are shown in Figure 1.2.

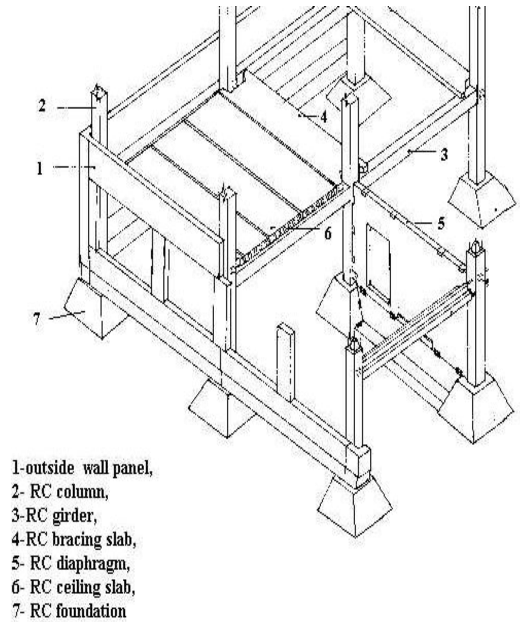


Figure 1.2 An example of Frame Structure

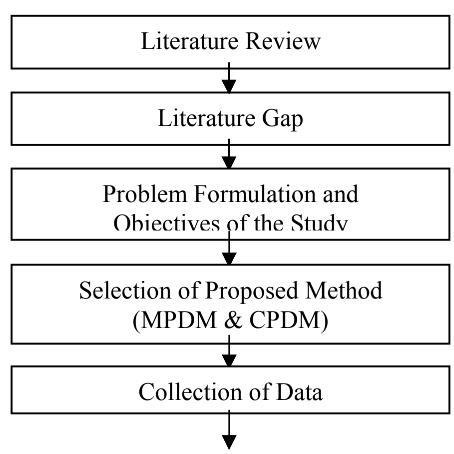
OBJECTIVE OF STUDY

After finding literature gap following objectives (theoretical evaluation of the proposed system) have been framed for present study;

- To analysed (Method Productivity Delay Model & Construction Productivity Delay Model) of Precast Concrete System.
- Identify the various factors influencing the selection of precast concrete and its productivity and to improve plant and onsite production.

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.



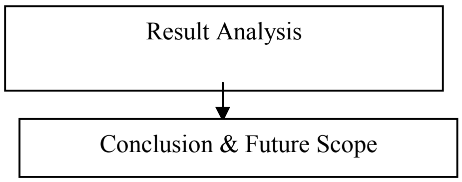


Figure 3.1 Research Methodology

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 analysed 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.

VIII. PROCESS FOR DELAY DURATION ANALYSIS

A common method of calculating delay duration is performed by comparing as planned schedule and as-built schedule written by CPM (Kraiem and Diekmann 1987; Bubshait and Cunningham 1998). Critical path is changed not commonly by schedule delay and acceleration (Arditi and Robinson 1995). The works on the critical path influence ultimately the delay of project completion. Construction works consists of millions or thousands of works and the works might be performed usually in different conditions from the point of planning. Those works can be classified by two types. The one type is impacting works caused adversely by impact factors to the completion day. The other type is un-impacting works to the completion day. So it is needed to analyse which work impact the completion date of the project and its impact degree and then we can examine the responsibility of the delay causes. An analysis of the delay duration could be processed according to the following procedure. The method process of calculating delay duration considering lost productivity is shown in Figure 3.2.

EQUATIONS FOR CALCULATING WORK DELAY DURATION

1. Lost Productivity (LP) means the loss of productivity caused by unknown variable or
2. Impact Factor (IF) occurring during the construction phase.
3. Lost Productivity Duration (LPD) can be defined as opportunity duration as much as

Lost Productivity Quantities (LPQ), which could be worked during un-impacted, works duration

IX. CONSTRUCTION PRODUCTIVITY DATA MODEL

The proposed calculating method is based on the construction productivity database which construction data can be cumulated in during the construction phase. Generally, the evident claim data such as contract documents, drawings, specifications, and any other documents related to contracts can be used to prove the direct impact causes, but they are not sufficient to prove the indirect impact causes such as lost productivity. It calculating method requires a construction productivity database containing related data to be collected during a construction phase. The below are a conceptual and a logical construction productivity data model that were developed to be used conceptually in this study.

X. Previous study of construction claim database

The method for calculating schedule delay is based on the data. Database can be used to collect diligently the data, which cannot be cumulated during construction phase. However schedule delay studies using database are insufficient. Knoke and Jentzen (1994) pointed out the limitation of the CPM network schedule as delay calculating tool and emphasized the reliability of evidence maintained in the database during the construction phase.

XI. Construction productivity data model

A typical implementation of the data model includes a collection and analysis of data requirements, conceptual data modelling and logical data modelling. Logical data modelling can be performed based on the real world and change a substance into a structured and detail information. Physical data modelling can be performed based on the system.

XII. Collection and analysis of data requirements

The most important thing of data model is collection and analysis of the requirements which are collected through the existing document, questionnaire and interviews with experts can be summarized the entity: space, work, work day, method, subcontractor, drawing number, spec, check list, material, documents, labour, machine, impact factor and so forth.

XIII. Conceptual construction productivity data model

Conceptual data model is based on examining the relations of entities for making an ER Model through analysing the requirements. For measuring the construction productivity can be drawn as Impact Factors (IF) impacts the Work Space as a relation of Work and Space like Figure 6. The works are associated with the Spec., Drawing, Machine, Material, and Checklist performed according to the space order. Work Space has documents related to as participants' change orders and subcontractors' labours, labour information, IF information, space, etc.

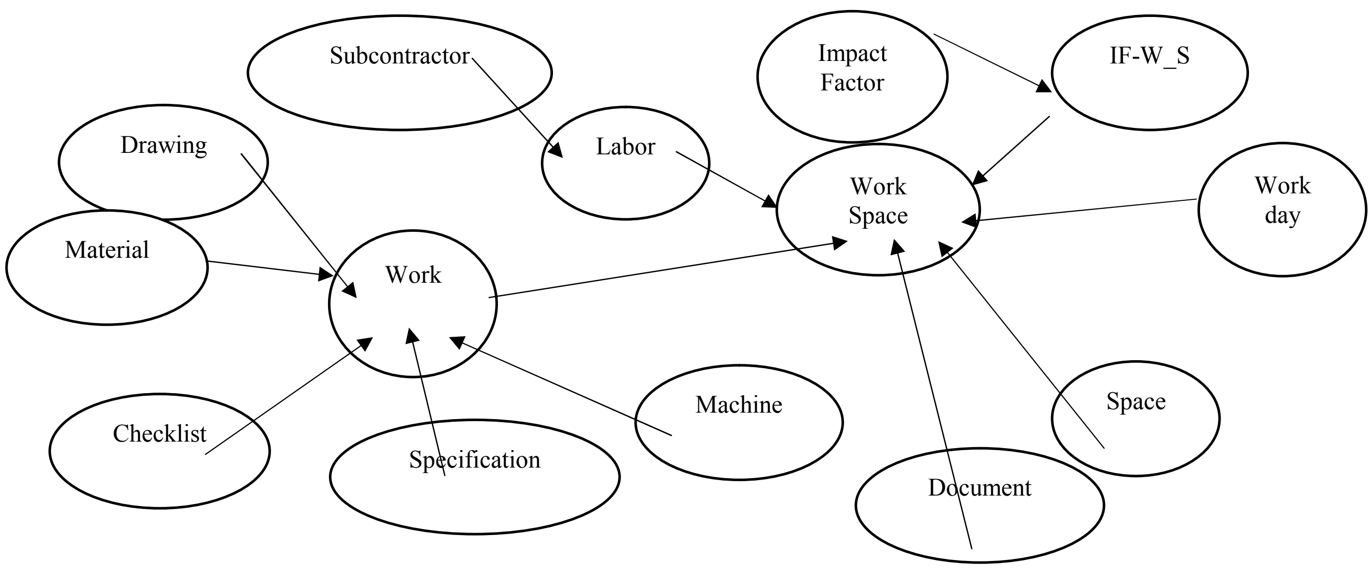


Figure : Conceptual construction productivity data model

EQUATIONS FOR CALCULATING WORK DELAY DURATION

1. Lost Productivity (LP) means the loss of productivity caused by unknown variable or
2. Impact Factor (IF) occurring during the construction phase.
3. Lost Productivity Duration (LPD) can be defined as opportunity duration as much as
4. Lost Productivity Quantities (LPQ), which could be worked during un-impacted, works duration.

Table :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

CONCLUSION

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 3.4) 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. This study is purely theoretical evaluation of the designed objectives.

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