Journal of Advances and Scholarly Researches in Allied Education
Vol. XV, Issue No. 2, (Special Issue) April-2018, ISSN 2230-7540

Precast Factory Management

Mr. Pradip Pawar[1]* Prof. A. A. Warudkar[2]

[1] PG Student, Civil Engineering Department, JSPM's ICOER, Pune, Maharashtra, India

[2] Professor, Civil Engineering Department, JSPM's ICOER, Pune, Maharashtra, India

Abstract – Rapid economic growth and limited availability of affordable land have restricted the horizontal mode of construction leading to vertical construction in most of the Indian cities. Urban India is mostly marked by tall buildings that are being built. Due to the economic slowdown and some governmental interventions, these building projects are seeing significant time and cost overrun, ultimately impacting the end-user. As these market pressures rise more and more, real estate developers are considering adopting emerging technologies to compensate for these construction issues. Indian construction industry is undergoing a paradigm shift from traditional methods of construction to modern methods of construction. Precast technology is one such move which is expected to enhance the productivity of the construction process, thereby, optimizing the requirement of resources on the site, reducing waste generation and resulting in a faster delivery of the projects. While internationally precast technology is considered as a mature technology, in India, it is not widely utilized, despite the advantages. Commonly cited constraints are high costs in comparison to traditional construction, economies of scale, logistics, skill level required, end user friendliness, etc. Primarily, this study focuses on identifying the challenges faced by the precast technology under various categories. This study also presents a cost analysis model for precast technology versus traditional construction to address some of the challenges. Presented cost model is applied to two projects wherein precast technology and conventional technology are utilized to construct the project and an inference is drawn comparing the time and cost aspects of precast technology. The present study reviles the past work done in scenario of precast factory management.

---------------------------------x---------------------------------

1. INTRODUCTION

The construction industry outsources and receives many advantages from prefabrication and precast concrete manufacturing such as saving time and overall cost, due to enabling concurrent different production lines; increasing constructability, and reducing congestion on site due to changing from an uncontrollable work environment on site to a controllable one in factories. Precast concrete manufacturers (or precasters) are involved in a construction project team as suppliers or subcontractors who produce, deliver, and elect precast components.

Precast products used in the construction industry are both catalogued and bespoke products. Those catalogued products have been well designed and produced, like ordinary manufacturing products, in a make-to-stock fashion whilst the bespoke products are designed and produced to meet requirements of a particular construction project. The bespoke products therefore are make-to-order production style. They are unique and require longer lead-time and more sophisticated production management for precasters to coordinate with the design and construction team of a construction project.

The production process review helps to understand considerations, practices, and procedures of the processes. Then, lean construction concepts are implemented to address problems in the processes and to provide sensible solutions. After that, a new methodology using data integration, artificial intelligence technologies, and a flow-shop scheduling technique is developed. Finally, the paper outlines a framework for developing an automatic production planning system called artificial intelligence planner (AIP). The requirements, specifications, and functionalities of the AIP are described. Its components are also explained.

1.2 The Precast Industry

Bespoke precast production process consists of three main processes namely product design, production planning, and shop floor manufacturing. Only the first two processes concerned with generating and managing product data are briefly reviewed. The design process, which is an upstream process, has an impact on the planning process because product design is the main source of input for planning. The production processes from a case study of precast concrete façades of an office building are described as follows.

1.2.1 Product Design Process

Product design is the process of developing all product definitions. Precasters, as subcontractors or suppliers, gather the project designs from a project designer team, which are not prepared for precast work to do their own product detailed designs and they have to ensure that both architectural and engineering requirements of the project are met.

Precast designers initiate precast general arrangement drawings (PGAD). PGAD are key drawings, which demonstrate how the façade is broken down into pieces, how they are jointed together, how they are fastened to the structure behind, and what their appearances are on the building. The important criteria for economic designs are to make precast pieces as large as practicable and identical as many as possible in order to minimize the number of moulds and to increase repetitive work. Since precast units are cast in purpose-built moulds, effective mould-reuse helps reduce the unit cost of products. Although the iteration of mould use means cost saving, the production program is longer due to waiting time for mould availability. PGAD are later used by many successive processes particularly precast planners use them for preparing the bill of quantities (BOQ), delivery schedule and production planning.

1.2.2 Production Planning Process

Production planning is the process that gathers necessary information to analyze and issue the production schedule, and controls the shop floor manufacturing progress. Precast planners receive product information from the design process to perform the planning process. They assign identifications to all designed precast pieces, group the similar pieces to the same product families, and decide number of moulds required. A purpose-built mould is prepared for the largest piece in the family with inserts or adjusts to reduce the mould size for smaller pieces of the same general form. This enables the reuse of moulds for several pieces.

The planners arrange a production plan regarding two constrained requirements: the current workload and the construction project schedule from contractors. Contractors could make a request of product delivery related to their construction progress on site. The planners and the contractors agree upon their own constraints to create a product delivery schedule. The precasters' current workload is analyzed and tuned along with the factory capacity whilst achieving the delivery schedule. The planners estimate manufacturing workload of a new project into the production plan. The manufacturing workload is expressed in terms of casting hours which are the aggregate of the number of hours for fabricating precast pieces based on the their size, difficulty of the design, and materials procurement.

The production schedule is arranged by simply applying the earliest due date rule and the experience-based estimation. The planners assign a production sequence and estimate the manufacturing time required for the products. Products with the earliest due dates are placed in the first order and the next product in this fashion.

1.2.3 Correction and Control Efforts

Precasters spend substantial time and tedious efforts on preparing PGAD due to many parties being involved in the design process of construction projects i.e. architects, engineers, and/or trade specialists. In most cases, construction projects do not have enough time to allow each party to finish their design in turn. Rather these parties develop the project designs in a concurrent manner. Precasters usually suffer from incomplete design information that comes from the project designer team (both architects and engineers). Precasters have to use that information but they spend several man-hours in order to check for any mistake, mismatch, missing, or ineptness in it. Precasters are prone to many changes that might occur from the project designer team at any time. Precasters absorb many risks from those changes and incorrect design information.

In addition, a precast production schedule can be revised many times. Not only can the project design team affect the precast production planning but also the contractors who directly request the product delivery. The construction schedule is revised quite often due to many variations on site and consequently the delivery schedule is revised. A change in product delivery dates causes disturbances to precasters, as they have to reallocate their constrained resources over the current workload and reschedule their production plan. These changes consume time and efforts of the planners and causes waiting times of the other successive procedures, and they fluctuate the optimum resource allocation level of precasters. Moreover, there is no guarantee that the earliest due date rule provide the optimum production sequence.

1.2.4 Lead-Time Characteristic

Precasters are facing the problem of a long production process lead-time. It is necessary that definitions of production time be clearly understood. Scientist defined that cycle time is a random variable relating the time it takes for a job. Unlike cycle time, lead time is a management constant used to indicate the anticipated or maximum allowable cycle time for a job. Customer lead-time is the amount of time allowed to fill a customer order from start to finish. In a make-to-stock environment, the customer lead-time is close to zero because products are ready to serve when customer arrives. In a make-to-order environment, the customer lead-time is the time that customers allow the company to design, produce, and deliver an item. For the case when variability is present, the customer lead-time must be greater than the average cycle time in order to have acceptable serviceability.

Lead-time is characterized by an asymmetric distribution, mostly skewed to the right. If something intervenes in the production system, the impact on the customer lead-time is more likely to extend time rather than to decrease it. Remedies to those interventions might be rework, idle waiting time, congestion, or correction. The longer lead-time means cost to the precasters. The large right side variation in Figure 1 shows that the precasters are not good at rectifying a confrontation, and their production system is not sound. Moreover, the precasters lose their competitiveness from a longer customer leadtime. Two possible ways to reduce customer lead-time can be to shorten (mode of) cycle time and to narrow the variation.

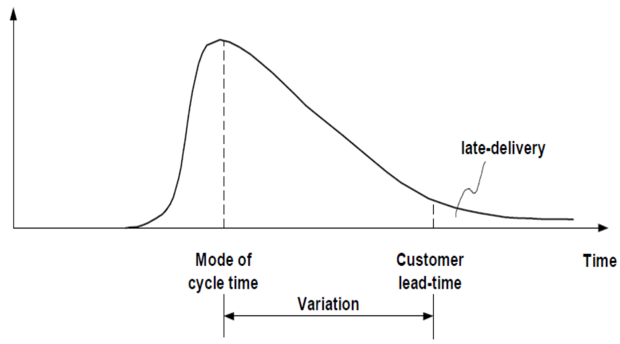

Figure No. 1.1: Cycle time distribution

1.3 Lean

Lean construction concepts have evolved from the lean production system in the automobile manufacturing. The concepts aim to eliminate all investigated waste using continuous improvement strategy toward an ideal waste-free production system. However, construction and manufacturing are different. Some might say that construction is more unique work with less repetition, so there are fewer advantages from learning curve or fewer chances of improving the routines; more complex organization with highly uncertain environments that means it is difficult to plan and control the project. Construction is likely to produce more waste so it really needs lean concepts.

1.3.1 Waste

Lean concepts perceive waste in the production process as any resources that are spent on the process but neither adds value to the final products nor conforms to the customer requirements. Waste can be quantified in terms of time, cost, and quantity. Scientist have classified waste in the production process in many different forms i.e. overproduction, over qualification, waiting time, transportation, inefficient processing, inventories, unnecessary movement, defects (under qualification), and others. In terms of time resource elaborated waste in the cycle time in the following equation.

Cycle time = processing time + inspection time + waiting time + transporting time + Correction time

Only processing time adds more value to final products, the others do not. Lean concepts are suggested to shorten the cycle time by improving the efficiency of the processing and by eliminating non-value-adding times that are inspection time, waiting time, transporting time, and correction time. These non-value-adding times are consequences of the variations in the processes as depicted in Figure 1.1.

Indeed, Precasters, as serving the construction industry, are encountering long customer lead-time due to long cycle time for manual production processes (focusing on product design and production planning) and long buffer time for anticipated variations. Since it is difficult to predict the number of changes from imperfect project designs and uncertain product delivery schedules but every change means repeating the manual production process. Precasters have to set a large buffer time for that. Therefore, this study considers waste in the precast production process from repetition of manual correction efforts caused by changes in the precast product design and the production planning.

1.3.2 Improvement

Scientist suggested that construction could be conceived as a prototype (one-of-a kind) production, which normally is accomplished by consistently debugging errors in design and production plans. There is little opportunity to learn and thoroughly correct designs and plans from a completed project for reuse on a subsequent similar project. Therefore, imperfect designs and unsound construction plans are quite common, and it is more likely that the whole supply chain including precasters would also interfere with changes as the debugging attempts. The improvement issue is how to relieve those efforts and time, and/or reduce the chances of occurrences. Two research studies that aim to improve the precast concrete industry are reviewed below.

The first one is from the Lean Construction Institute. Scientist introduced a new production management approach called decoupling buffer for precasters. The decoupling buffer is used for absorbing the variations of customer orders and shielding precasters from producing unwanted products. The strategy is to divide the manufacturing process into two stages: pre-manufacturing and final products manufacturing. Precasters are suggested to prepare production information, and pre-manufacturing elements rather than straightaway manufacture the final products. Only when there is a pull from near order, probably in weekly time, prior to delivery dates, the final products are made.

The other ongoing research is being conducted by the Precast Concrete Software Consortium. PCSC are developing an automated, comprehensive design system for precast industry. The system aims to automate precast design and the drafting process. It also assists the precast designers by combining architectural, engineering, and precast manufacturing designs together in one attempt. That means all three concerning aspects would be considered at the same time. This system is expected to reduce mismatches in the designs and the customer lead-time spent on precast design and drafting work.

Apart from that, this paper outlines the research that aims to reduce the efforts and time for precast production planning by proposing the AIP. The main objectives of the AIP are to integrate data from the design to planning processes by eliminating paper-based data; to reduce tedious human efforts for repetitive work on correction or revision of planning; to improve production planning method by using flow-shop scheduling technique; and to generate the production schedule automatically for the precast manufacturing factory. By preparing product designs, the AIP system retrieves all relevant product information, analyzes it with all conventional planning considerations, and automatically outputs a production schedule. The AIP uses the flow-shop scheduling technique to model the precast manufacturing process and to optimize the schedule. The AIP is anticipated to replace human interpretation and intuition efforts for production planning. Precasters also could revise the design or reschedule the plan faster with fewer exertions, as the changing information is perceived by the automated system can amend the other relevant information at one time.

The AIP system implements the methodology to reduce customer lead-time for bespoke precast products. The cycle time for production planning is reduced by the automation and the variation is decreased by releasing human involvement. Moreover, the AIP could be integrated with the PCSC's system to provide a completed integration system of precast product design and production planning.

1.4 Background

Industry management issues, such as enterprise resource planning (ERP) and supply chain management (SCM), are discussed and implemented successfully in many manufacturing industries but construction. No matter what the nature of construction is manufacturing buildings, risks and uncertainties make its characteristic different to other manufacturing industries. In order to reduce effects of these two scourges, precast is an evolutional method what is adopted to remove construction work environment from outdoor to indoor and make the procedure of component producing regular as an automatic factory. Thus, precast method is a construction method with its industrial characteristics being closest to those of manufacture industry. However, Practical plans and information identification in working process must be further recognized and achieved. This study proposes an optimization model which focuses on planning issues of precast manufacturing procedure.

The storage and transportation planning of a construction precast project is mainly discussed herein. Generally, whole process of a precast project can be divided into 5 stages: design, production, storage, transportation, and installation. Besides, at least 4 important roles: client, architect, subcontractor, and precast factory, are involved in these 5 stages. Relationships among these four roles depend on contracts of a project. From perspective of the precast factory, two stages are out of their control: design stage and installation stage. In design stage, the architect confirms details of all precast components, such as shape, strength and material, with the client, and then makes components exact. The precast factory receives these component details and then produces components according to architect's designs as orders. In installation stage, the subcontractor installs all completed components at where the places according to architect's design. The precast factory supplies components on time in the installation stage of most cases. It is obvious that the design stage and the installation stage involve two or more roles. Thus, production, storage, and transportation stage are more controllable than these two stages from precast factory's viewpoint. Furthermore, production stage was the issues most frequently investigated and analyzed in prior precast management related study. However, the planning of storage and transportation are still very significant to a precast factory. To complete the management mechanism of precast factory, these two stages need to be investigated.

- To study the raw material quality and maintenances system with a proper questionnaire survey.

- To study the existing resource management system in the precast factory with a proper interview with the manager.

- To analyse the waste generated and their process to handle and recycle waste.

- To analyse add on tools for RFID and PDA for product management and its cost effect.

II. LITERATURE REVIEW

[1] The precast industry is a supplier of building materials CO the construction industry. It is capital intensive and the instability of construction demand makes investment in the industry a high risk undertaking. As a result, a highly structured and efficient scheduling system is required to maximise the utilisation of resources and minimise the waste associated with them.

[2] Bidding and production decisions, including the estimation of optimal mark-up on price, represent major decision problems for companies formulating a successful business strategy. The objective of this research was to develop a strategy for developing an integrated bidding/production management expert system to assess the suitability of incoming enquiries for a particular company and suggests a 'bid/no bid' decision. If a decision to bid is taken then the expert system should provide advice on the optimal mark-up to maximise the chance of winning potential contracts. The system developed in this paper is composed of an information system that integrates design, estimation and production planning, and a knowledge-base to provide abstracted information and advice to managers in charge of bidding. The information system analyses the records of previous contracts and presents managers with vital information that minimise the risk of poor decisions associated with bidding. The knowledge-base is composed of intelligent rules which were elicited from previous contract records and experienced managers in charge of bidding. They are designed to advise managers on two major issues: bid/no bid and estimation of optimal tender price. A number of factors that affect bidding strategies were identified from reviewing previous bidding methodologies and surveying eight major companies in the UK by means of semi-structured interviews. Copyright 0 1996 Civil-Comp Limited and Elsevier Science Limited.

[3] The demand for the concrete products is seasonal and huge stock is built in winter for dispatch in summer. As 1000–2000 products with different sizes, weights, handling and stacking requirements are involved, the process of deciding appropriate locations to stock the products and track them while loading into lorries for dispatch becomes complex. Stockyards in the precast concrete products industry are experiencing space congestion, and long vehicle waiting times for both the storage and retrieval of concrete products due to lack of a proper methodology to manage stockyard layouts and their operations. This paper describes an ongoing research that addresses the stockyard layout management problem through the development of an integrated simulation and visualisation model. The paper focuses on the development of the visualisation and simulation element of the stockyard management system sim Stock. The simulation model has been developed using ARENA/SIMAN, a general-purpose simulation language.

[4] The construction industry is a major generator of waste material. Construction waste should be minimized at source and if we are to significantly reduce the level of construction waste designers should consider reducing construction waste during the design process. The majority of construction waste is generated from the concreting process. In general, any reduction in on-site concreting leads to waste reduction. Precasting and prefabrication therefore offers significant opportunities for the reduction of waste. If precasting is adopted there are significant implications for the design phase of the project. Additional information is needed by design staff and construction expertise is required as part of the design process. This paper shows how information modelling and Design Structure Matrix (DSM) techniques enable designers to model and understand the implications of such decisions within the detailed design process.

[5] Managing for sustainability is considered to be critical to the development of corporate sustainability, and is fundamentally about strategic organizational development and change. This paper presents the key findings from four case studies undertaken to

investigate how the leaders in corporate sustainability in the UK precast concrete industry were managing for sustainability. It was found that by adopting a compliance approach, characterized by the development of management systems and continuous performance improvement cultures, the four companies studied were engaged in the activities and developing the capabilities necessary to manage for sustainability, and had progressed naturally to the 'efficiency' phase of corporate sustainability.

[6] The integrated design optimization, not only the element optimization, is considered a strong trend. The integrated optimization involves the three major stages of an engineering design process namely conceptual design, embodiment design and detailing design. This paper presents an integrated structural precast floor design optimization tool, called DSSPF (Decision Support System for Precast Floors), for precast concrete structures using GA and considers the cost impact at all construction phases like manufacture, transport and erecting in the structural conception. An example indicating the DSSPF results are very consistent with the results of an existing design is further presented. Based on the results obtained, the DSSPF is considered a powerful novel tool to assist designers in the choice of structural layout and initial element dimensioning phases.

[7] The buildings and construction sector is one the most important economic sectors all over the world but, at the same time, one of the most pollutant emitting and resource demanding. This study focuses on the analysis of the entire main input inventory data used for assessing the environmental impacts linked to the life cycle of a pre-cast concrete shed: great importance was given to the use of on-site collected specific data which was carefully verified for assuring its quality and reliability. The study was conducted in accordance with the ISO standards 14040 and 14044 (2006), with the aim of qualifying and quantifying the resources, the materials and the energy demand for the shed construction, use and end of life phases. The study results show that for the four phases taken into account in the system boundaries (production of the raw materials, construction of the shed, use of the shed and end-of-life of the shed) the most inventories are in the shed construction phase because of the huge amount of materials, fuels and resources such as concrete, steel, electrical energy and water. Other inventories are related: to the use phase, for the huge consumption of electrical energy for indoor heating and cooling; to the maintenance phase, for the number of units, such as fixtures and power plant, which are to be replaced; and to the end-of-life phase for the number of data needed for modelling the shed disassembly.

[8] Buildings are one of the primary contributors to carbon emissions. Given the small size of construction site and increasing housing demand in Hong Kong, precast concrete has been frequently adopted in not only public residential buildings, but also the private sector. This study compares the carbon emissions of precast and traditional cast-in-situ construction methods based on a case study of a private residential building in Hong Kong. Life cycle assessment (LCA) model is established to consider the system processes from cradle to end of construction. The comparison is conducted based on eight scenarios at four levels, i.e. cubic meter concrete, precast facade, group of façade elements, and an apartment. It is found that the carbon emission of the studied residential apartment is 669 kg carbon dioxide equivalent per one square meter floor area. Precasting can lead to 10% carbon reduction for one cubic meter concrete.

[9] Taking into account the global environmental problems, there is the urgent need to reduce energy consumption and the greenhouse gas emissions in the construction sector. Environmental awareness can be achieved through the extensive application of precast systems in buildings construction. A multi-criteria analysis has been used to obtain energy-efficient precast walls for Zero Energy Building in warm climate focusing on eco-friendly building materials. The mode FRONTIER optimization tool, with the use of computational procedures developed in Mat lab, has been used to assess the thermal dynamics of building components.

[10] Resource scheduling of construction proposals allows project managers to assess resource requirements, provide costs and analyse potential delays. The Manufacturing, transportation and Assembly (MtA) sectors of precast construction projects are strongly linked, but considered separately during the scheduling phase. However, it is important to evaluate the cost and time impacts of consequential decisions from manufacturing up to assembly. In this paper, a multi-objective Genetic Algorithm-based (GA-based) searching technique is proposed to

solve unified MtA resource scheduling problems (which are equivalent to extended Flexible Job Shop Scheduling Problems). To the best of the authors' knowledge, this is the first time that a GA-based optimisation approach is applied to a holistic MtA problem with the aim of minimising time and cost while maximising safety. The model is evaluated and compared to other exact and non-exact models using instances from the literature and scenarios inspired from real precast constructions.

[11] As an effective strategy for improving the productivity of the construction industry, prefabricated construction has attracted concerns worldwide. This study investigated the life-cycle energy use of prefabricated components and the corresponding effect on the total embodied energy use for a number of real building projects. Result showed that the life-cycle energy use of prefabricated components ranged from 7.33 GJ/m3 for precast staircase to 13.34 GJ/m3 for precast form. The recycling process could achieve 16%e24% energy reduction. This study also found that apart from reusability, energy savings are also obtained from waste reduction and high quality control, saving 4%e14% of the total life-cycle energy consumption. All these advantages can be regarded as important environment friendly strategies provided by precast construction. The linear regression analysis indicated that the average increment in energy use was nearly linearly correlated with prefabrication rate. Precast facade and form are identified as energy-intensive components compared with the conventional construction method. Therefore, the challenge lies in improving the integrality and quality of the prefabrication technique while reducing its dependence on energy-intensive materials. Besides, attention should be focused on improving the maturity of the precast market to avoid additional energy consumption during prophase investigation.

[12] Nowadays, the design of Zero Energy Buildings requires a technology of light multi-layered walls and the envelope represents a key element to reach high level of thermal behaviour and indoor comfort. This paper illustrates a method based on a multi-criteria analysis for the design of energy-efficient precast walls in the cold climate. It encourages the use of eco-friendly building materials and local materials, in accordance with the directions of the Building Sustainable Protocols, like LEED and Itaca. The designed methodology involves the use of Mat Lab rel.7.0 for the computational procedure and the mode FRONTIER rel.4.3 optimization tool to evaluate the dynamic behaviour of the building components and to obtain a multitude of high efficiency configurations. The optimization has been performed in terms of steady thermal transmittance, periodic thermal transmittance, decrement factor, time shift, areal heat capacity, thermal admittance, surface mass, thickness, supply and installation costs and ecofriendly score. Furthermore, hygro-thermal and acoustic check have been evaluated for three walls, selected between the most efficient. The walls present no interstitial condensation. The results highlights that it is possible to rich high efficiency precast walls also by thin and ultra-thin thicknesses.

[13] This paper presents a quantitative environmental impact assessment tool for the decision making of construction processes including structures, infrastructures and buildings by means of an Environmental Impact Index (EII) to be applied at design and/or construction stages. The research is based on multi-attribute utility theory, interviews with experts representatives of the different stakeholders in construction, and an analysis of fifty-nine European and Spanish environmental legislative acts. The resulting tool was applied to two construction alternatives for road drains (one precast and one cast-in-place). The findings show that the tool enables the prioritisation of construction processes and the selection of the best alternative in terms of environmental impact and that the results are stable to reasonable weight variations. The tool contributes to decision making in the context of project management in construction: it can help professionals in public administration, and design and construction companies. It helps to quantify the cradle-to-gate impact of construction work, which has usually been less studied than the operational impact in the life-cycle assessment of buildings. The tool is being piloted in construction projects of the Barcelona City Council.

[14] Current precast production scheduling methodologies have limited applicability in practice due to the neglect of real-world production circumstances. To improve, a two-hierarchy simulation-GA hybrid model for precast production is developed to (1) specialize the operations of precast

production according to their characteristics, (2) incorporate the uncertainty in processing time in practice, and (3) model the process-waiting time on the flow of work based on the genetic algorithm and discrete event simulation. In the proposed model, the trade-off can be achieved between the conflicting goals of the on-time delivery of precast components and minimum production cost, and the production resources configuration is optimized to cut down resource waste. Finally, a real case study is conducted to test the validity of TSGH_PP approach. The developed model fills the gap in simulation system design and methodology for precast production, and increases the applicability of precast production scheduling methods in real construction projects.

[15] Construction and demolition waste (CDW) accounts for 30% to 40% of the total amount of waste in China. CDW is usually randomly dumped or disposed in landfills and the average recycling rate of CDW in China is only about 5%. Considering there is big challenge in adoption of circular economy in CDW industry in China while related research is still limited, we conduct the CDW management analysis through 3R principle. Existing policies and management situations were investigated and analyzed based on the reduction, reuse and recycle principles. Results reveal that primary barriers of reducing CDW in China include lack of building design standard for reducing CDW, low cost for CDW disposal and inappropriate urban planning. Barriers to reuse CDW include lack of guidance for effective CDW collection and sorting, lack of knowledge and standard for reused CDW, and an under-developed market for reused CDW. As for recycling of CDW, key challenges are identified as ineffective management system, immature recycling technology, under-developed market for recycled CDW products and immature recycling market operation. Proposals to improve the current situation based on 3R principle are also proposed, including designing effective circular economy model, reinforcing the source control of CDW, adopting innovative technologies and market models, and implementing targeted economic incentives.

III. CONCLUSION

Rapid economic growth and limited availability of affordable land have restricted the horizontal mode of construction leading to vertical construction in most of the Indian cities. Urban India is mostly marked by tall buildings that are being built. Due to the economic slowdown and some governmental interventions, these building projects are seeing significant time and cost overrun, ultimately impacting the end-user. As these market pressures rise more and more, real estate developers are considering to adopt emerging technologies to compensate for these construction issues. Indian construction industry is undergoing a paradigm shift from traditional methods of construction to modern methods of construction. Precast technology is one such move which is expected to enhance the productivity of the construction process, thereby, optimizing the requirement of resources on the site, reducing waste generation and resulting in a faster delivery of the projects.

While internationally precast technology is considered as a mature technology, in India, it is not widely utilized, despite the advantages. Commonly cited constraints are high costs in comparison to traditional construction, economies of scale, logistics, skill level required, end user friendliness, etc. Primarily, this study focuses on identifying the challenges faced by the precast technology under various categories. This study also presents a cost analysis model for precast technology versus traditional construction to address some of the challenges. Presented cost model is applied to two projects wherein precast technology and conventional technology are utilized to construct the project and an inference is drawn comparing the time and cost aspects of precast technology. Amicable solutions are proposed for adoption of precast construction from an Indian perspective.

IV. REFERENCES

Andrew Baldwin, Chi-Sun Poon B. Li-Yin Shen, et. al. (2009). "designing out waste in high-rise residential buildings: analysis of precasting methods and traditional construction", renewable energy, vol.34, pp. 2067–2073.

Augusto T. De Albuquerque, Mounir K. El debs & Antonio M.C. Melo, (2012). "a cost optimization-based design of precast concrete floors using genetic lgorithms", automation in construction, vol. No. 22, pp. 348–356.

B. Anvari, P. Angeloudis & W.Y. Ochieng, (2016). "a multi-objective ga-based optimisation for holistic manufacturing, transportation and assembly of precast construction", automation in construction, vol. No.71, pp. 226–241.

Beijia Huanga, Xiangyu Wang, et. al. (2018). "construction and demolition waste management in china through the 3r principle", resources, conservation & recycling, vol. 129, pp. 36–44.

Carlo Ingrao, Agata lo Giudice, et. Al., (2014) "life cycle inventory analysis of a precast reinforced concrete shed for goods storage", journal of cleaner production, pp. 1-16.

Cristina Baglivo & Paolo Maria Congedo, (2016). "high performance precast external walls for cold climate by a multi-criteria methodology", energy, vol.115, pp. 561-576.

Cristina Baglivo, Paolo Maria Congedo (2015) "design method of high performance precast external walls for warm climate by multi-objective optimization analysis", energy, vol. No.90, pp. 1645-1661.

Ian Holton, Jacqui Glass & Andrew D.F. Price, (2010). "managing for sustainability: findings from four company case studies in the uk precast concrete industry", journal of cleaner production, vol. 18, pp. 152–160.

Jingke Hong, Geoffrey Qiping Shen & chao mao, (2016). "life-cycle energy analysis of prefabricated building components: an inputeoutput-based hybrid model", journal of cleaner production, vol. 112, pp no.2198-2207.

Maria Del Mar Casanovas-Rubio & Gonzalo Ramos, (2017). "decision-making tool for the assessment and selection of construction processes based on environmental criteria: application to precast and castin-situ alternatives", resources, conservation & recycling, vol. 126, pp. 107–117.

N. N. Dawood, (1995). "scheduling in the precast concrete industry using the simulation modelling approach", building and environment, vol. 30, no. 2, pp. 197-207.

N. N. Dawood, (1996). "a strategy of knowledge elicitation for developing an integrated bid&ng/production management expert system for the precast indrnstry", advances in engineering software, vol.25, pp. 225-234.

Nashwan Dawood & Ramesh Marasini, (2002). "Visualisation of a stockyard layout simulator simstock: a case study in precast concrete products industry", automation in construction, vol.12, pp. 113– 122.

Ya Hong Dong, Lara Jaillon & Peggy Chu et. al. (2015) "comparing carbon emissions of precast and cast-in-situ construction methods – a case study of high-rise private building", construction and building materials, vol.99, pp. 39–53.

Zhaojing Wanga, Hao Hua & Jie Gongb, (2018). framework for modeling operational uncertainty to optimize offsite production scheduling of precast components, automation in construction, vol. No. 86, pp. 69–80.

Corresponding Author

Mr. Pradip Pawar*

PG Student, Civil Engineering Department, JSPM's ICOER, Pune, Maharashtra, India