

SIMULATION OF INDUSTRIALISED BUILDING SYSTEM COMPONENTS PRODUCTION

Abdul Kadir Marsono¹, Masine Md. Tap², Ng Soon Ching³ & Ahmad Mahir Makhtar⁴

¹&⁴ Assoc. Prof., PhD., Department of Structure and Materials, Faculty of Civil Engineering, UTM.

³ Postgraduate, MSc Construction Management, Faculty of Civil Engineering, UTM.

² Lecturer, PhD., Department of Production and Industrial Engineering, Faculty of Mechanical Engineering, UTM.

Abstract: The construction of IBS building should start with the production of the IBS components and the production process is the main activity concerned in the IBS production plant. Having an optimum production line to manufacture the required IBS elements within targeted time and limited number of reusable steel mould is very important. In this study, workstation organization method has been adopted in the production of IBS component of beam and column. Witness 2001 simulation software has been used to model and simulate the most optimum production line set up. Here, two production lines set up have been proposed to complete the production of IBS beam and column between two and three months time with limited number of reusable steel mould to supply for the construction of medium size single storey IBS housing project ranging from 100 to 300 units. A contingency production line set up which able to complete the production of required IBS components within a month time with increased number of reusable steel mould has also been proposed. Number of resources such as workstation, tool, storage area and labour has been determined from the proposal. The proposed production line can be applied in the planning and cost estimating of IBS production plant set up.

Keywords : Industrialised Building System (IBS), IBS Production Line, Manufacturing.

INTRODUCTION

Industrialised Building System (IBS) is not new in the Malaysian construction industry, particularly the usage of steel structures and precast concrete for the construction of bridges, drains and other infrastructure projects. IBS that enables off-site prefabricated components manufactured at factories enable cost saving and quality improvement through construction standardization and reduction of labour intensity. On top of that, minimal wastage, less site material, a cleaner and neater environment as well as superior quality controlled may lead to lower total construction costs.

The heart of IBS construction starts with the production of the components by the precaster. In fact, it is a high-risk investment for the precaster to venture in producing IBS components due to large capital precast plant set up cost and the instability of construction demand. Hence, the precast concrete industry is very challenging as the precasters compete among themselves for business opportunities, technology and quality in production and market reputation. They have to maintain a good reputation in the market by fulfilling the requirements and specifications set by the client in terms of cost, quality, time and consultation. Therefore, a highly structured planning and operation system is required to manage the production of IBS components in order to optimize the profit and productivity as well as to survive in the global market.

Problem Statement

IBS components such as beam and column are produced in the precast plant with superior “in-door” quality control and supervision. There are a few important aspects that the precaster needs to consider before venturing into this business. The needs to properly plan the layout of the precast plant as well as equipments and machineries needed, hiring of skilled labours as well as general workers, having enough capital to run the operation are required. A good planning on resources will enable the precaster to meet the supply of IBS elements to their client in time.

Basically, there are two alternatives of work organization available for the production of IBS component that are all-purpose team method and workstation method. The precaster has to carefully consider on which work organization method to be applied in the production of IBS component as each of these work organizations has their own advantages and disadvantages. However, the appropriateness and efficiency of these two-work organization methods is highly depends on the volume of production, number of workers engaged, facilities used and time.

Objective and Scope

The main objectives of this paper are:

- (i) To propose the optimum production line set up to manufacture the amount of IBS beam and column required for the construction of a medium size single storey IBS housing project within two months and three months time and with limited number of reusable steel mould.
- (ii) To propose a contingency production line set up to produce the amount of IBS beam and column required for the construction of a medium size of single storey IBS housing project in one month time with increased number of reusable steel mould.
- (iii) To determine the number of resources such as labour, machinery, tool and storage area required in the proposed production line set up.

The scope of this paper is mainly limited to the production of IBS components namely beams and columns required for the construction of single storey IBS housing project ranging from 100 to 300 units. The production process that highlighted in this paper begins from the preparation of parts until the curing process. In simulation, limited number of reusable steel mould available in the production plant is the only constraint. The number of mould used for the production is 125 units for beam and 75 units for column while the number of reusable steel mould increase to 300 units for beam and 100 units for column for contingency plan.

The number of workers involved and the time used to produce the IBS components were observed at the pilot plant and the time required was clocked using stopwatch. The total amount of IBS components needed for this medium size single storey IBS housing project was extracted from a 100% IBS house as shown in Figure 1. There are some assumptions made in this study such as the production will not be interrupted due to machine breakdown, lack of labours and insufficient supply of raw materials or parts. The effective working hour for the production plant is six hours per shift and the production plant is operated in a minimum of one shift and maximum of three shifts per day.

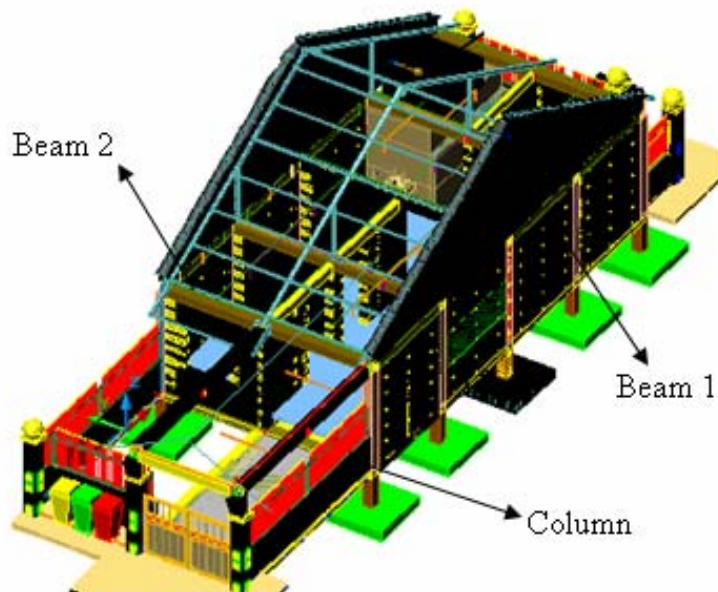


Figure 1 Prototype of single storey medium cost IBS house

The proposed production line suggested from this study can be applied in the planning of IBS pilot plant set up. The estimated cost of the production line can be calculated from the proposal that includes the number of workstation or machinery as well as labour required. This study also testifies that Witness 2001 simulation software can be used in to model and simulate an optimum production line set up for IBS production.

STUDY OF METHOD OF IBS COMPONENT PRODUCTION

There are three steps used in carrying out this feasibility study. The steps are data collection, modeling and simulation using manufacturing software Witness 2001 and finally analysis of data.

Data Collection

Three important raw data has been collected form the conventional construction sites namely the production time, number of IBS components required and the layout of the plant. The production of IBS components consists of several processes and activities whereby stopwatch was used to clock the time needed in each activity. The total amount of IBS beam and column needed for a medium size single storey IBS housing project were extracted from 100% IBS single storey house as in Figure 1. The layout of the production plant is according to the pilot plant set up.

Modeling and Simulation

Witness 2001 software is used to model and simulate the production of IBS components. With the collected data, a model is developed and simulated to obtain the optimum production line set up with limited number of reusable steel mould.

Data Analysis

From the results of the simulation, it is interpreted to show the time, resources and storage area needed to complete the required number of IBS components for a medium size single storey IBS housing project ranging from one hundred to three hundred houses. Basically, there are two results obtained from this study. The first part is on the IBS components production time and resources required as shown in Table 1. The total amount of IBS beam and column required is shown in Table 2 while the pilot plant layout has two production lines one is for beam and the other one is column as shown in Figure 2 and Figure 3.

Table 1 : Production Time

Activity	Time (Mins)	Labour	Equipment
Main Bars Preparation	5	2 unskilled	1 unit of Cutter
Plates Fabrication	15	1 skilled	1 set of Cutter and Welding Equipment
Spiral Links Preparation	27	1 skilled	1 unit of Spiral Link Machine
Steel Mould Assembly	40	2 skilled	Hand Tools
Fixing Rebar	12	2 skilled	1 unit of Welding Machine
Degreasing	10	1 unskilled	1 unit of Spray
Concreting	24	2 skilled	1 unit of Vibrating Table
Demoulding and Inspection	25	1 unskilled	Hand Tools
Mould Cleaning and Reassembling	40	1 unskilled	Hand Tools

Table 2 : IBS Components Required

No. of House	IBS Element	Beam 1 200 x 300 x 3400	Beam 2 300 x 300 x 6800	Column 300 x 300 x 3300
	100		1745	805
200		3490	1610	1470
300		5235	2415	2205

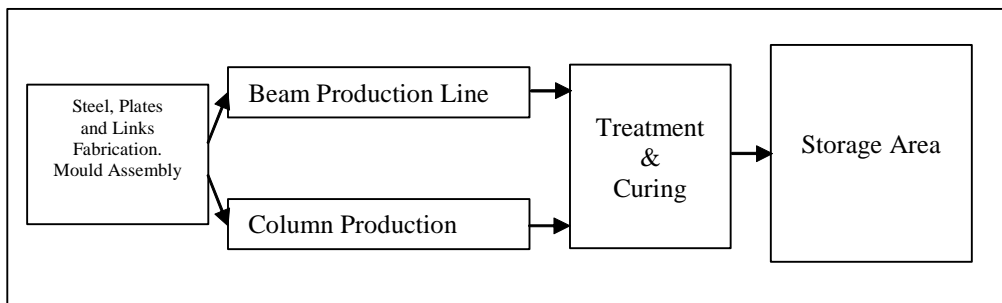


Figure 2 : IBS Plant Layout

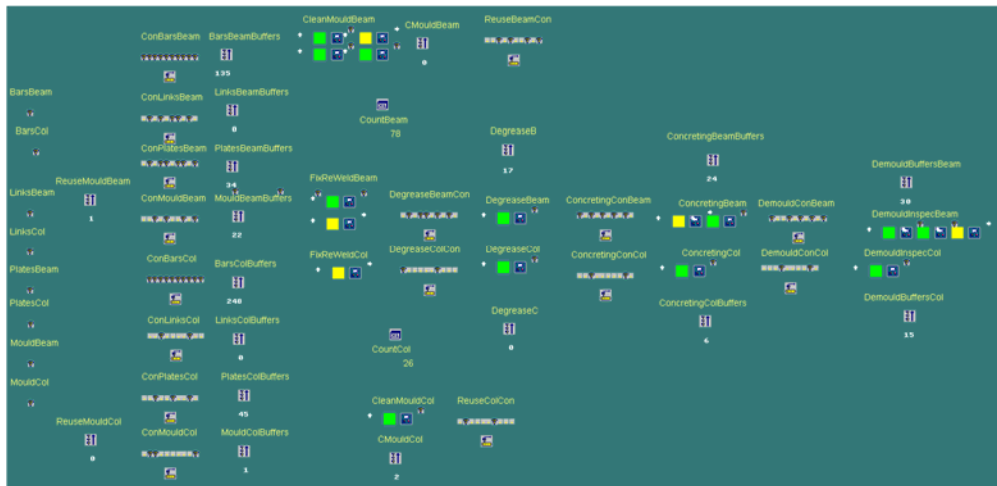


Figure 3 : Simulation of IBS Plant Layout

The second part of the result is obtained from the simulation. These results can be divided into overall production time and resources needed for producing IBS beams and columns and it are shown at Table 3 and Table 4.

Table 3 : Overall Production Time

Time (Mins)	1 Month			2 Months			3 Months		
	100 Houses	200 Houses	300 Houses	100 Houses	200 Houses	300 Houses	100 Houses	200 Houses	300 Houses
Targeted Time	10800	21600	32400	21600	43200	64800	32400	64800	97200
Actual Time (Beam)	9941 (28 days)	20861 (29 days)	32165 (30 days)	29851 (58 days)	41611 (58 days)	75547 (70 days)	31047 (87 days)	62007 (87 days)	92967 (87 days)
Actual Time (Column)	9267 (26 days)	18443 (26 days)	27979 (26 days)	18821 (53 days)	37556 (53 days)	56291 (53 days)	27347 (76 days)	57476 (80 days)	87587 (82 days)

Table 4 : Resources Required

Activity	Workstation			Labour					
	1 Month	2 Months	3 Months	1 Month		2 Months		3 Months	
				S	U	S	U	S	U
Main Bars Preparation	3	2	2	-	6	-	4	-	4
Plates Fabrication	9	5	3	9	-	5	-	3	-
Spiral Links Preparation	11	6	4	11	-	6	-	4	-
Steel Mould Assembly	19	7	5	38	-	14	-	10	-
Fixing Rebar	6	3	3	12	-	6	-	6	-
Degreasing	6	3	2	-	6	-	3	-	2
Concreting	10 (59)	5 (63)	3 (84)	20	-	10	-	6	-
Demoulding and Inspection	10 (360)	5 (178)	4 (117)	-	10	-	5	-	4
Mould Cleaning and Reassembling	14 (177)	7	5 (62)	-	14	-	7	-	5
Total				90	36	41	19	29	15

- S - Skilled Labour
- U - Unskilled Labour
- (X) - storage area required to temporary store the amount of IBS elements before the process

DISCUSSION

Two months and three months production line set up has performed very well to produce the required number of IBS components within the targeted time with limited number of reusable steel mould of 125 units for beam and 75 units for column. However, two months production line set up has failed to complete the production of IBS beam element in time for 300 houses demand. It has exceeded for ten days time to complete the required number of IBS beam element. In fact, the production line has performed to its optimal whereby the reason for not producing the required IBS beam in time is due to insufficient number of reusable steel mould. The impact of insufficient steel mould becomes more critical when the production is carried out more than two shifts. It is because three shifts production required longer period of detention time for the mould to stay at the setting area before it can be demoulded. The production is sometimes interrupted as there is no steel mould supply due to the longer detention time. For contingency production line, the production of IBS elements is within the targeted time as the number of reusable steel mould has increased.

The increased in the number of resources such as workstation and labour has shorten the production time whereby one month production line set up required the greatest number of resources. Most of the resources in contingency plan increased doubly compared to two months and three months production line set up. However, steel mould assembly process is the most critical activity as the number of workstation and labour for one month production line has increased to almost three folds compared to two months and three months production line set up.

Temporary storage area (buffer in Witness 2001) is required in the production plant near to the workstation to store the in-process IBS elements especially at the curing process. The storage areas in the production plant are concentrated at the end of the production process. However, temporary storage area to store parts such as main bars, steel plates, steel moulds and links is required at fixing and welding of rebar's workstation at the beginning of the production process. The area required to temporarily keep the inventory is larger for the contingency plan compared to two months or three months production line at the demoulding and inspection workstation because contingency plan has a greater number of reusable steel mould and therefore it has a greater number of wet IBS components to be stored for at least one day before it can be demoulded.

CONCLUSION

From this study, there are three significant conclusions that can be drawn. They are:

- (i) Optimum production line set up has been proposed to complete the production of IBS beam and column required for the construction of medium sized single storey IBS housing project within two months and three months time with limited number of reusable steel mould.
- (ii) Contingency production line set up with increase number of reusable steel mould to produce the amount of IBS beam and column required for the construction of a medium size of single storey IBS housing project in one month time has been proposed.
- (iii) Number of resources such as labour, machinery, tool and storage area required in the production plant has been determined.

It is also recommended that:

- (i) An analysis of cost based on the proposed production set up can be determined in order to indicate the budget required for the plant set up.
- (ii) Reduce the set time by using concrete additives and simultaneously will reduce the requirement of pricey steel formwork.
- (iii) Contingency simulation in the case machinery breakdown may also be simulated.

REFERENCES

1. Chan, W.T. and Hu, H. (2002). "Production Scheduling for Precast Plants using a Flow Shop Sequencing Model". *Journal of Computing in Civil Engineering*. pp 165-174
2. Lew, Y.L., Hassim, S. and Kadir, M.R.A. (2003). "Factors Contributing to Cost Control Problems in Malaysia IBS Construction". *International Conference on Industrialised Building Systems, Kuala Lumpur, Malaysia*.
3. Richardson, J.G. (1991). "Quality in Precast Concrete". *Longman Scientific & Technical*. Pp 252-274.
4. Shaari, S.N. (2003). "Dirty, Difficult and Dangerous? Simplify It...Use IBS!", *Buletin Jurutera, The Institution of Engineer of Malaysia (IEM)*, June 2003, pp. 7-10
5. Trikha, D.N. (1999). "Industrialised Building Systems, Prospect in Malaysia". *Proceedings of World Engineering Congress, Sarawak, Malaysia*.
6. Warszawski, A. (1999) "Industrialized and Automated Building Systems". *E&FN Spon*. pp 116-179.
7. Yuosre, F.B., Kadir, M.R.A. and Ahmed, H.H. (2002). "Industrialised Building Systems Construction in Malaysia". *Journal of Architectural Engineering*. pp 19-23.