Application of lean production principle in construction project: Case study of segment casting phase in Ahmedabad Metro Rail Project

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Abstract:

Research Question/Hypothesis: Why construction industry having poor management? When, where and at which activity of construction get disturbed production system? What is the solution/recommendation for solving the reason for poor management?

Purpose: How modern management method based construction system is more effectively beneficial and productive as compare to traditional construction system by focusing on detailed reasons for getting late in time, over in budget and poor thinking for safety, health & wealth awareness of resources in construction project in India and then recommend way of solution.

Research Design/Method: Based on lean production principle by applying in different activities of construction project, mention reasons and recommend solution after data collection and analysis.

Findings: Easily find out the difference between traditional construction and modern management based construction system.

Limitations: Think practically not ideally, can't innovate but recommendation for better management.

Implications: Underestimated this hard work by higher authorities of construction project and have to stop this work after giving recommendation due limitation of being a student.

Value for practitioners: How to get find out of purpose of applying lean production principle in construction project.

Keywords: Lean Construction Case study, Lean concept in Construction Paper type: Case study

Research Objective/Aim

To conduct research to access significance of lean production principle in construction project to minimize various types of waste(s) and then by increase efficiency of timely completion of project with effective utilization of resources with incorporating proper health and safety of workers.

- The following objectives are need to be achieved to fulfil above mention aim for research.
- 1. Examine case study, to check the effects of lean principle on productivity of any construction project.
- 2. To identify VAT, NVAT and Waste in Ahmedabad Metro Rail project and set recommendation for effective execution of project.

Introduction of Construction Project

Ahmedabad metro rail project phase-1 is the project of MEGA (Metro Express Link between Gandhinagar and Ahmedabad) projects. This project having 2 routes for connecting north end to south end and east end to west end.

North end to south end named as south-north corridor which is from APMC market (south end) to Motera stadium (north end) and east end to west end named as east-west corridor which is from Vastral gam (east end) to Thaltej gam (west end).



Figure 1:-Alignment of Ahmedabad Metro Rail Project Phase – 1^[1]

Having two route of the total project,

Route-1 East-West corridor from Thaltej Gam to Vastral Gam, having 20.737 km total length which include 14.402 km length of via-duct and 6.335 km length of underground and 17 numbers of station which include 13 elevated and 4 underground.

Route-2 North-South corridor from APMC to Motera Stadium, having 18.522 km length of via-duct and 15 numbers of elevated station. Having a 4 phase in construction of bridge in Ahmedabad metro rail projects, which are given below:

- 1 Construction of pile
- 2 Construction of pile cap to pier cap
- 3 Segment casting
- 4 Erection of segment

Author has applied Lean production principle in 1st and 3rd phase of construction of pile segment casting at casting yard at north end of south-north corridor.

Segment casting

Limitations of Case Study

- Applying lean production principle in any one product base.
- Major parameter is time, so application of lean production principle should be focused on time
- Limited only for particular site only
- Construction method, plan, requirement and resource neither be change nor recommended for change.

Consideration in Construction Project

Research Methodology

Method for data collection

Author have to take out full and constant readings, without breakage in any major/effective cycle through observation from construction project. If it's not possible to take readings through observation due to certain limits like being student/intern/trainee unable to stay on site at particular time, stay connected with authorized person at site and take out all activity readings.

Method for data analysis

- Find Customer requirement
 - Study in detail what exactly customer/client needs, should be describe in all parameters like quality, time, quantity, condition, material, formats, methods and techniques.
- Divide time in N-VAT & VAT & Waste Convert all process/activity cycle time in to non-value added time, value added time and waste for every resources, machine power and man power.
- Make value stream mapping, cardiogram and bar chart
 - Make a diagram of value stream mapping, cardiogram and bar chart for all process and add time and cost in this diagram.Remove excess activities
 - Remove excess activities which doesn't affect client/customer's requirement.
 - Conclusion
 - Recommendation

Data collection

Segment Casting Data-01

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		3:30 AM	6:30 AM	3:00	Inner
	4	6:30 AM	7:30 PM	13:00	WW3
		7:30 PM	9:30 PM	2:00	Concreting
		9:30 PM	12:00 AM	2:30	NVAT1

		12:00 AM	9:30 PM	21:30	NVAT1
	5	9:30 PM	12:00 AM	2:30	WW1
		12:00 AM	12:45 PM	12:45	WW1
		12:45 PM	1:15 PM	0:30	Deshuttering
	6	1:15 PM	2:30 PM	1:15	NVAT2
	6	2:30 PM	4:15 PM	1:45	Deshuttering
		4:15 PM	5:05 PM	0:50	WW1
		5:05 PM	6:45 PM	1:40	Deshuttering
		6:45 PM	8:35 PM	1:50	Outer shutter
	7	8:35 PM	9:30 PM	2:30 WW1 12:45 WW1 0:30 Deshuttering 1:15 NVAT2 1:45 Deshuttering 0:50 WW1 1:40 Deshuttering	Inserting Reinforcement cage
	/	9:30 PM	10:30 PM	1:00	Fixing bulkhead
		10:30 PM	12:00 AM	1:30	Profiling
		12:00 AM	1:15 AM	1:15	Profiling
		1:15 AM	2:05 AM	2:30 WW1 12:45 WW1 0:30 Deshuttering 1:15 NVAT2 1:45 Deshuttering 0:50 WW1 1:40 Deshuttering 1:50 Outer shutter 0:55 Inserting Reinforcement cage 1:00 Fixing bulkhead 1:30 Profiling 1:15 Profiling 0:50 OPG6 8:25 Inner 1:30 WW3 2:00 Concreting 10:00 NVAT1 3:00 WW7 1:35 Deshuttering 1:40 Outer shutter 1:15 DW6 0:45 Inserting Reinforcement cage 1:45 DW6 9:00 DW6 2:00 Profiling 3:00 WW7 2:15 Inner 1:45 DW6 9:00 DW6 2:00 Profiling 3:3	OPG6
S3U	0	2:05 AM	10:30 AM	8:25	2:30 WW1 12:45 WW1 0:30 Deshuttering 1:15 NVAT2 1:45 Deshuttering 0:50 WW1 1:40 Deshuttering 0:50 WW1 1:40 Deshuttering 0:50 WW1 1:40 Deshuttering 0:51 Inserting Reinforcement cage 1:00 Fixing bulkhead 1:30 Profiling 0:50 OPG6 8:25 Inner 1:30 WW3 2:00 Concreting 10:00 NVAT1 14:00 NVAT1 14:00 NVAT1 1:35 Deshuttering 1:40 Outer shutter 1:15 DW6 0:45 Inserting Reinforcement cage 1:45 DW6 0:00 PW6 2:00 Profiling 3:00 WW7 2:15 Inner 7
	8	10:30 AM	12:00 PM	1:30	
	1	12:00 PM	2:00 PM	2:30 WW1 12:45 WW1 0:30 Deshuttering 1:15 NVAT2 1:45 Deshuttering 0:50 WW1 1:40 Deshuttering 1:50 Outer shutter 0:55 Inserting Reinforcement cage 1:00 Fixing bulkhead 1:30 Profiling 1:15 Profiling 0:50 OPG6 8:25 Inner 1:30 WW3 2:00 Concreting 10:00 NVAT1 3:00 WW7 1:35 Deshuttering 1:40 Outer shutter 1:15 DW6 0:45 Inserting Reinforcement cage 1:45 DW6 9:00 DW6 2:00 Profiling 3:00 WW7 2:15 Inner 7:45 WW3 2:30 WW3 3:30 Concreting 1:50 Outer shutter 0:40 Inserting Reinforcement ca	
		2:00 PM	12:00 AM	2:30 WW1 12:45 WW1 0:30 Deshuttering 1:15 NVAT2 1:45 Deshuttering 0:50 WW1 1:40 Deshuttering 1:50 Outer shutter 0:55 Inserting Reinforcement cage 1:00 Fixing bulkhead 1:30 Profiling 1:15 Profiling 0:50 OPG6 8:25 Inner 1:30 WW3 2:00 Concreting 10:00 NVAT1 14:00 NVAT1 14:00 NVAT1 14:00 NVAT1 1:40 Outer shutter 1:15 Deshuttering 1:40 Outer shutter 1:15 DW6 0:45 Inserting Reinforcement cage 1:45 DW6 9:00 DW6 2:00 Profiling 3:00 WW7 2:15 Inner 7:45 WW3 2:30 WW3 <	
		12:00 AM	10:30 AM 8:25 Inner 12:00 PM 1:30 WW3 2:00 PM 2:00 Concreting 12:00 AM 10:00 NVAT1 2:00 PM 14:00 NVAT1 5:00 PM 3:00 WW7 6:35 PM 1:35 Deshuttering		
	9	2:00 PM	5:00 PM	3:00	WW7
	2:00 PM 12:00 A 9 12:00 AM 2:00 PM 2:00 PM 5:00 PM 5:00 PM 5:00 PM 6:35 PM	6:35 <mark>PM</mark>	1:35	Deshuttering	
		6:35 PM	8:15 PM	1:40	Outer shutter
	9	8:15 PM	9:30 PM	1:15	DW6
	9	9:30 PM	10:15 PM	0:45	Inserting Reinforcement cage
		10:15 PM	12:00 AM	1:45	DW6
		12:00 AM	9:00 AM	9:00	DW6
S4U(M)		9:00 AM	11:00 AM	2:00	Profiling
	10	11:00 AM	2:00 PM	3:00	WW7
		2:00 PM	4:15 PM	2:15	Inner
		4:15 PM	12:00 AM	7:45	WW3
	11	12:00 AM	2:30 AM	2:30	VW1VW1VW1DeshutteringVV1DeshutteringVW1DeshutteringDuter shutternserting Reinforcement cageixing bulkheadrofilingPG6nnerVW3DoncretingDuter shutterDeshutteringDuter shutterDV00D000 <td< td=""></td<>
	11	2:30 AM	6:00 AM	0:30 Deshuttering 1:15 NVAT2 1:45 Deshuttering 0:50 WW1 1:40 Deshuttering 1:50 Outer shutter 0:55 Inserting Reinforcement cage 1:00 Fixing bulkhead 1:30 Profiling 1:15 Profiling 1:15 Profiling 1:15 Profiling 0:50 OPG6 8:25 Inner 1:30 WW3 2:00 Concreting 10:00 NVAT1 14:00 NVAT1 14:00 NVAT1 1:35 Deshuttering 1:40 Outer shutter 1:15 DW6 0:45 Inserting Reinforcement cage 1:45 DW6 9:00 DW6 2:00 Profiling 3:00 WW7 2:15 Inner 7:45 WW3 2:30 WW3	
		9:30 PM	11:20 PM	1:50	Outer shutter
		11:20 PM	12:00 AM	0:40	Inserting Reinforcement cage
		12:00 AM	12:45 AM	0:45	Fixing bulkhead
		12:45 AM	2:15 AM	1:30	Profiling
S5U	6	2:15 AM	3:00 AM	0:45	Inner
320	M) 12:00 AM 9:00 AM 9:00 9:00 AM 11:00 AM 2:00 11:00 AM 2:00 11:00 AM 2:00 PM 3:00 2:15 4:15 PM 2:15 4:15 PM 12:00 AM 2:30 7:45 11 11 12:00 AM 2:30 AM 2:30 2:30 11 12:00 AM 2:30 AM 2:30 3:30 9:30 PM 11:20 PM 1:50 11:20 PM 1:50 11:20 PM 12:00 AM 0:40 2:45 4:45 6 12:00 AM 2:15 AM 1:30 2:15 AM 1:30 3:00 AM 7:00 AM 4:00 4:00 1:00 1:00	WW3			
		7:00 AM	5:05 PM 0:50 WW1 6:45 PM 1:40 Deshuttering 8:35 PM 1:50 Outer shutter 9:30 PM 0:55 Inserting Reinforcement ca 10:30 PM 1:00 Fixing bulkhead 12:00 AM 1:30 Profiling 115 AM 1:15 Profiling 2:05 AM 0:50 OPG6 10:30 AM 8:25 Inner 12:00 PM 1:30 WW3 2:00 PM 2:00 Concreting 12:00 PM 1:30 WW7 6:35 PM 1:35 Deshuttering 8:15 PM 1:40 Outer shutter 9:30 PM 1:15 DW6 10:15 PM 0:45 Inserting Reinforcement ca 12:00 AM 1:45 DW6 9:30 PM 1:15 DW6 10:15 PM 0:45 Inserting Reinforcement ca 12:00 AM 2:00 Profiling 2:00 PM 3:00 WW7 4:15 PM 2:15	Concreting	
		8:30 AM	12:00 AM	12:45 WW1 0:30 Deshuttering 1:15 NVAT2 1:45 Deshuttering 0:50 WW1 1:40 Deshuttering 1:50 Outer shutter 0:55 Inserting Reinforcement ca 1:00 Fixing bulkhead 1:30 Profiling 1:15 Profiling 0:50 OPG6 8:25 Inner 1:30 WW3 2:00 Concreting 10:00 NVAT1 14:00 NVAT1 3:00 WW7 1:35 Deshuttering 1:40 Outer shutter 1:15 DW6 0:45 Inserting Reinforcement ca 1:45 DW6 9:00 DW6 2:00 Profiling 3:00 WW7 2:15 Inner 7:45 WW3 2:30 WW3 3:30 Concreting 1:50 Outer shutter 0:40 Inserting Reinforcement ca<	NVAT1
	7	12:00 AM	8:30 AM	8:30	NVAT1
	7	8:30 AM	11:30 AM	3:00	Deshuttering

Segment Casting Data-02

g Data-02	D	Time		Dur.	Activity	
Seg. id	Day	Start	End	(m)	Activity	
		10:35 AM	11:55 AM	1:20	Outer shutter	
		11:55 AM	12:10 PM	0:15	Reinforcement cage	
		12:10 PM	1:00 PM	0:50	Fixing Bulkhead	
		1:00 PM	2:00 PM	1:00	NVAT2	
		2:00 PM	PM 3:45 PM 1:30 Profiling PM 3:55 PM 0:10 WW7 PM 5:55 PM 2:00 Profiling	Fixing Bulkhead		
	3:45 PM 3:55 PM 0:1 3:55 PM 5:55 PM 2:0	1:30	Profiling			
		3:45 PM	3:55 PM	0:10	WW7	
		3:55 PM	5:55 PM	2:00	Profiling	
		5:55 PM	6:15 PM	0:20	WW17	
S2D		6:15 PM	:55 PM 6:15 PM 0:20 WW17 :15 PM 9:55 PM 3:40 Inner	Inner		
	9:55 PM 12:00 AM 2:05	WW3				
		12:00 AM	4:30 AM	4:30	WW3	
	12:00 AM 2 4:30 AM	7:30 AM	3:00	Concreting		
		7:30 AM	12:00 AM	16:30	NVAT1	
		12:00 AM	7:30 AM	7:30	NVAT1	
		7:30 AM	1:00 PM	5:30	WW1	
	3	1:00 PM	2:00 PM	1:00	NVAT2	
		2:00 PM	4:15 PM	2:15	WW1	
		4:15 PM	6:10 PM	1:55	Deshuttering	
		6:10 PM	7:00 PM	0:50	Outer shutter	
		7:00 PM	7:20 PM	0:20	Reinforcement cage	
	2	7:20 PM	8:45 <mark>PM</mark>	1:25	WW4	
	3	8:45 PM	9:30 PM	0:45	Activity 1:20 Outer shutter 0:15 Reinforcement cage 0:50 Fixing Bulkhead 1:00 NVAT2 0:15 Fixing Bulkhead 1:30 Profiling 0:10 WW7 2:00 Profiling 0:20 WW17 3:40 Inner 2:05 WW3 3:40 Inner 2:05 WW3 3:40 Korreting 1:50 NVAT1 7:30 NVAT1 7:30 NVAT1 7:30 NVAT2 2:15 WW1 1:00 NVAT2 2:15 WW1 1:50 Deshuttering 0:50 Outer shutter 0:20 Reinforcement cage 1:25 WW4 0:45 Fixing Bulkhead 2:00 Profiling 0:30 WW2 1:00 Concreting 3:00 Inmer	
		9:30 PM	11:30 PM	2:00		
		11:30 PM	12:00 AM	0:30	WW7	
		12:00 AM	3:00 AM	3:00	Inner	
620		3:00 AM	8:00 PM	0:15 Fixing Bulkhead 1:30 Profiling 0:10 WW7 2:00 Profiling 0:20 WW17 3:40 Inner 2:05 WW3 3:40 KW3 4:30 WW3 3:00 Concreting 16:30 NVAT1 7:30 NVAT1 5:30 WW1 1:00 NVAT2 2:15 WW1 1:00 NVAT2 2:15 Deshuttering 0:50 Outer shutter 0:20 Reinforcement cage 1:25 WW4 0:45 Fixing Bulkhead 2:00 Profiling 0:30 Inner 1:00 OPG1 2:00 WW2 1:00 Concreting 3:00 Inner 1:00 Concreting 3:00 NVAT1 3:00 NVAT1 3:00 NVAT1		
S3D	4	8:00 PM	10:00 PM	2:00	D:15 Reinforcement cage D:50 Fixing Bulkhead D:00 NVAT2 D:15 Fixing Bulkhead D:10 WW7 D:10 WW7 D:00 Profiling D:10 WW7 D:20 WW17 D:20 WW3 D:20 Concreting MVAT1 MVAT1 D:00 NVAT2 D:15 Deshuttering D:20 Reinforcement cage D:20 Reinforcement cage D:20 Reinforcement cage D:20 Profiling D:20 Reinforcement cage D:20 Reinforcement cage D:20 WW4 D:45 Fixing Bulkhead D	
		10:00 PM	11:00 PM	1:00		
		11:00 PM	12:00 AM	1:00	Concreting	
	5	12:00 AM	3:00 AM	3:00	Concreting	
	5	3:00 AM	12:00 AM	21:00	NVAT1	
		12:00 AM	3:00 AM	3:00	NVAT1	
	6	3:00 AM	8:30 AM	5:30	WW1	
		8:30 AM	10:00 AM	1:30	Deshuttering	
		10:00 AM	11:30 AM	1:30	Outer shutter	
		11:30 AM	12:00 PM	0:30	DW4	
S4D	6	12:00 PM	12:15 PM	0:15	Reinforcement cage	
		12:15 PM	1:00 PM	0:45	Fixing Bulkhead	
		1:00 PM	2:00 PM	1:00	NVAT2	

		2:00 PM	12:00 AM	10:00	DW5
		12:00 AM	12:45 AM	0:45	DW5
		12:45 AM	3:20 AM	2:35	Profiling
		3:20 AM	6:05 AM	2:45	DW5
	7	6:05 AM	7:30 AM	1:25	Inner
		7:30 AM	8:00 AM	0:30	OPG1
	7 8 9 10	8:00 AM	12:00 AM	16:00	Public Holiday
	8	12:00 AM	8:00 AM	8:00	Public Holiday
		8:00 AM	9:15 AM	1:15	WW6
		9:15 AM	1:00 PM	3:45	WW3
		1:00 PM	2:00 PM	1:00	NVAT2
		2:00 PM	6:15 PM	4:15	WW3
		6:15 PM	8:00 PM	1:45	NVAT1
		8:00 PM	12:00 AM	4:00	NVAT1
		12:00 AM	8:00 PM	20:00	NVAT1
		8:00 PM	12:00 AM	4:00	WW1
	4	12:00 AM	9:55 AM	9:55	WW1
	10	9:55 AM	1:00 PM	3:05	Deshuttering
	10	1:00 PM	2:00 PM	1:00	NVAT2
		2:00 PM	3:05 PM	1:05	Deshuttering
	10	3:05 PM	11:15 PM	8:10	WW7
	10	11:15 PM	12:00 AM	0:45	Outer shutter
		12:00 AM	12:30 AM	0:30	Outer shutter
		12:30 AM	2:50 AM	2:20	WW4
		12:00 AM8:00 AM8:00Public Holiday8:00 AM9:15 AM1:15WW69:15 AM1:00 PM3:45WW31:00 PM2:00 PM1:00NVAT22:00 PM6:15 PM4:15WW36:15 PM8:00 PM1:45NVAT18:00 PM12:00 AM4:00NVAT112:00 AM8:00 PM20:00NVAT112:00 AM9:55 AM9:55WW112:00 AM9:55 AM9:55WW19:55 AM1:00 PM3:05Deshuttering1:00 PM3:05 PM1:05Deshuttering3:05 PM11:15 PM8:10WW711:15 PM12:00 AM0:45Outer shutter12:00 AM0:30Outer shutter	Reinforcement cage		
		3:15 AM			2:35 Profiling 2:45 DW5 1:25 Inner 0:30 OPG1 16:00 Public Holiday 8:00 Public Holiday 1:15 WW6 3:45 WW3 1:00 NVAT2 4:15 WW3 1:45 NVAT1 4:00 NVAT1 20:00 NVAT1 4:00 WW1 9:55 WW1 3:05 Deshuttering 1:00 NVAT2 1:00 NVAT2 1:05 Deshuttering 8:10 WW7 0:45 Outer shutter 0:30 Outer shutter 0:30 Outer shutter 0:30 Profiling 4:00 PG6 1:00 Inner 1:00 NVAT2 4:30 Inner 5:30 WW3 3:00 WVAT1 5:00 NVAT1 5:00 NVAT1 5:00 NVAT1 <tr< td=""></tr<>
			5:00 AM	0:45	DW6
	11	5:00 AM	and the second	3:00	0:45DW52:35Profiling2:45DW51:25Inner0:30OPG116:00Public Holiday8:00Public Holiday1:15WW63:45WW31:00NVAT24:15WW31:45NVAT120:00NVAT120:00NVAT120:00NVAT21:05Deshuttering1:00NVAT21:05Deshuttering1:00NVAT21:05Deshuttering1:00NVAT21:05Deshuttering1:00NVAT21:05Deshuttering1:00NVAT21:05Deshuttering1:00NVAT21:05Deshuttering1:00NVAT21:00Fixing Bulkhead0:45DW61:00Inner1:00NVAT24:30Inner1:00NVAT11:00NVAT11:00NVAT11:00NVAT11:00NVAT11:00NVAT11:00W111:30Deshuttering2:30Outer shutter2:30Outer shutter2:30Outer shutter2:30Outer shutter2:30Outer shutter2:30Inner
			12:00 PM	4:00	
S5D				2:35 Profiling 2:45 DW5 1:25 Inner 0:30 OPG1 16:00 Public Holiday 8:00 Public Holiday 1:15 WW6 3:45 WW3 1:00 NVAT2 4:15 WW3 1:45 NVAT1 4:00 NVAT1 20:00 NVAT1 4:00 WW1 9:55 WW1 3:05 Deshuttering 1:00 NVAT2 1:00 Fixing Bulkhead 0:45 DW6 3:00 Profiling 4:00 OPG6 1:00 Inner 1:00 NVAT1 4:30 Inner 1:00 NVAT1 1:00 </td	
	12:00 AM12:45 AM0.45DW512:45 AM3:20 AM2:35Profiling3:20 AM6:05 AM2:45DW56:05 AM7:30 AM1:25Inner7:30 AM8:00 AM0:30OPG18:00 AM12:00 AM8:00Public Holiday8:00 AM9:15 AM1:15WW69:15 AM1:00 PM3:45WW31:00 PM2:00 PM1:00NVAT22:00 PM6:15 PM4:15WW36:15 PM8:00 PM1:45NVAT18:00 PM12:00 AM8:00NVAT1912:00 AM8:00 PM20:00NVAT18:00 PM12:00 AM4:00WW1100 PM2:55 AM9:55WW19:55 AM1:00 PM3:05Deshuttering10011:15 PM8:10WW71103:05 PM11:15 PM8:1011011:15 PM12:00 AM0:4511115 PM12:00 AM0:4511115 PM12:00 AM0:4511115 PM11:05Deshuttering11011:15 PM11:05Deshuttering11112:00 AM2:50 AM0:2211111:15 PM11:00Fixing Bulkhead11112:00 AM2:50 AM0:2511112:00 AM2:00 PM1:0011115:00 AM2:00 PM1:00112:00 AM2:00 PM1:00Inner12:00 PM1:00 PM1:				
	8:00 PM 12:00 AM 4:00 NVAT1 9 12:00 AM 8:00 PM 20:00 NVAT1 9 12:00 AM 8:00 PM 20:00 NVAT1 10 12:00 AM 9:55 AM 9:55 WW1 10 12:00 AM 9:55 AM 9:55 WW1 10 2:00 PM 3:05 Deshuttering 1:00 PM 2:00 PM 1:00 NVAT2 2:00 PM 3:05 PM 1:05 Deshuttering 10 3:05 PM 11:15 PM 8:10 WW7 11:15 PM 12:00 AM 0:45 Outer shutter 12:30 AM 2:50 AM 2:20 WW4 2:50 AM 3:15 AM 0:25 Reinforcement cage 3:15 AM 4:15 AM 1:00 Fixing Bulkhead 4:15 AM 5:00 AM 3:00 Profiling 8:00 AM 12:00 PM 4:00 OPG6 12:00 PM 1:00 Inner 1:00 PM 1:00 1:00 PM 2:00 P				
	11 5:00 AM 8:00 AM 3:00 8:00 AM 12:00 PM 4:00 12:00 PM 1:00 PM 1:00 1:00 PM 2:00 PM 1:00 2:00 PM 6:30 PM 4:30 6:30 PM 12:00 AM 5:30				
	12				
	6:3 12: 3:0 5:0 13				
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S7C	2:00 6:15 8:00 9 12:0 9 12:0 9 12:0 9:55 10 12:0 2:00 1:00 2:00 11:1 12:3 2:50 3:15 4:15 11 5:00 8:00 12:0 12:0 12:0 12:0 12:0 12:0 12:0 12:0 12:0 12:0 11:1 12:0 12:0 12:0 11:1 12:0 12:0 12:0 11:1 12:0 11:1 12:0 12:0 12:0 12:0 11:1 12:0 12:0 12:0 11:1 12:0 12:0 12:0 12:0 12:0 11:1 12:0 12:0 11:1 12:0 12:0 12:0 12:0 11:1 12:0 1				
	14	2:45 AM	3:20 AM		
		3:20 AM	4:00 AM	0:40	Fixing Bulkhead

		4:00 AM	6:15 AM	2:15	Profiling
		6:15 AM	10:00 AM	3:45	Inner
		10:00 AM	4:40 PM	6:40	WW3
		4:40 PM	6:30 PM	7:20	Concreting
		6:30 PM	12:00 AM	5:30	NVAT1
		12:00 AM	4:40 PM	16:40	NVAT1
	15	4:40 PM	9:00 PM	4:20	WW1
		9:00 PM	11:20 PM	2:20	Deshuttering
		4:00 PM	6:10 PM	2:10	WW7
	2	6:10 PM	7:50 PM	1:40	Outer shutter
	3	7:50 PM	8:15 PM	0:25	Reinforcement cage
		8:15 PM	12:00 AM	3:45	OPG5
		12:00 AM	8:15 AM	8:15	OPG5
		8:15 AM	9:00 AM	0:45	Fixing Bulkhead
		9:00 AM	11:20 AM	2:20	Profiling
	4	11:20 AM	1:00 PM	1:40	OPG1
	4	1:00 PM	2:00 PM	1:00	NVAT2
		2:00 PM	5:00 PM	3:00	WW7
S2U		5:00 PM	9:20 PM	4:20	Inner
		9:20 PM	12:00 AM	2:40	WW3
		12:00 AM	3:00 AM	3:00	DW3
	5	3:00 AM	7:00 AM	4:00	Concreting
		7:00 AM	12:00 AM	17:00	NVAT1
		12:00 AM	7:00 AM	7:00	NVAT1
		7:00 AM	1:00 PM	6:00	WW1
	6	1:00 PM	2:00 PM	1:00	NVAT2
	U	2:00 PM	4:30 PM	2:30	Deshuttering
		4:30 PM	5:00 PM	0:30	WW7
		5:00 PM	5:30 PM	0:30	Deshuttering
		5:30 PM	8:00 PM	2:30	WW7
	6	8:00 PM	9:55 PM	1:55	Outer shutter
	U	9:55 PM	10:30 PM	0:35	WW7
		10:30 PM	12:00 AM	1:30	IW1
		12:00 AM	7:00 AM	7:00	IW1
	7	7:00 AM	7:30 AM	0:30	Outer shutter
S3U	,	7:30 AM	8:00 AM	0:30	Reinforcement cage
550		8:00 AM	12:00 AM	16:00	Public Holiday
		12:00 AM	8:00 AM	8:00	Public Holiday
		8:00 AM	10:45 AM	2:45	WW6
	8	10:45 AM	12:25 PM	1:40	IW1
	U	12:25 PM	1:05 PM	0:40	Fixing Bulkhead
		1:05 PM	2:15 PM	1:10	NVAT2
		2:15 PM	4:10 PM	1:55	Profiling

4:10 PM 6:00 PM 1:50 DW1 6:00 PM 6:30 PM 0:30 NVAT2 6:30 PM 10:00 PM 3:30 OPG3 10:00 PM 12:00 AM 2:00 Inner 12:00 AM 2:00 Inner	
6:30 PM 10:00 PM 3:30 OPG3 10:00 PM 12:00 AM 2:00 Inner	
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12:00 AM 2:00 AM 2:00 Inner	
9	
12:00 AM 7:00 AM 7:00 NVAT1	
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9:00 PM 12:00 AM 3:00 Deshuttering	3:30 OPG3 2:00 Inner 2:00 Inner 2:00 WW3 3:00 Concreting 17:00 NVAT1 7:00 WW1
12:00 AM 8:00 AM 8:00 WW7	
8:00 AM 9:30 AM 1:30 Outer shutter	
9:30 AM 10:00 AM 0:30 Reinforcement cage	
10:00 AM 8:45 PM 10:45 OPG4	
8:45 PM 11:30 PM 2:45 OPG3	14:00 WW1 3:00 Deshuttering 8:00 WW7 1:30 Outer shutter 0:30 Reinforcement cage 10:45 OPG4 2:45 OPG3 0:30 Fixing Bulkhead 1:30 Fixing Bulkhead 1:30 Fixing Bulkhead 1:30 Fixing Bulkhead 2:15 Profiling 2:00 OPG6 4:30 Inner 2:30 WW3
11:30 PM 12:00 AM 0:30 Fixing Bulkhead	
12:00 AM 1:30 AM 1:30 Fixing Bulkhead	
1:30 AM 1:45 AM 0:15 DW2	
1:45 AM 4:00 AM 2:15 Profiling	
S4U 6:00 AM 10:30 AM 4:30 Inner	
12 10:30 AM 1:00 PM 2:30 WW3	
1:00 PM 2:00 PM 1:00 NVAT2	
2:00 PM 5:00 PM 3:00 WW3	0:30 NVAT2 3:30 OPG3 2:00 Inner 2:00 WW3 3:00 Concreting 17:00 NVAT1 7:00 NVAT1 7:00 NVAT1 14:00 WW1 3:00 Deshuttering 8:00 WW7 1:30 Outer shutter 0:30 Reinforcement cage 10:45 OPG4 2:45 OPG3 0:30 Fixing Bulkhead 1:30 Fixing Bulkhead 0:15 DW2 2:15 Profiling 2:00 OPG6 4:30 Inner 2:30 WW3 1:00 NVAT1 18:30 NVAT1 18:30 NVAT1 18:30 NVAT1 18:30 WW1 3:00 WW1 3:00 Deshuttering 0:40 WW7 2:15 Outer shutter
5:00 PM 6:30 PM 1:30 Concreting	
6:30 PM 12:00 AM 5:30 NVAT1	
12:00 AM 6:30 PM 18:30 NVAT1	0:30 NVAT2 3:30 OPG3 2:00 Inner 2:00 WW3 3:00 Concreting 17:00 NVAT1 7:00 NVAT1 7:00 NVAT1 14:00 WW1 3:00 Deshuttering 8:00 WW7 1:30 Outer shutter 0:30 Reinforcement cage 10:45 OPG4 2:45 OPG3 0:30 Fixing Bulkhead 1:30 Fixing Bulkhead 1:30 Fixing Bulkhead 1:30 Fixing Bulkhead 0:15 DW2 2:15 Profiling 2:00 OPG6 4:30 Inner 2:30 WW3 1:00 NVAT2 3:00 WW3 1:30 Concreting 5:30 NVAT1 18:30 NVAT1 18:30 NVAT1 3:00 Deshutteri
13 6:30 PM 12:00 AM 5:30 WW1	
12:00 AM 8:00 AM 8:00 WW1	
14 8:00 AM 11:00 AM 3:00 Deshuttering	
15 11:20 PM 12:00 AM 0:40 WW7	
12:00 AM 2:15 AM 2:15 Outer shutter	
2:15 AM 3:15 AM 1:00 DW5	
3:15 AM 4:00 AM 0:45 Reinforcement cage	2:00 WW3 3:00 Concreting 17:00 NVAT1 7:00 NVAT1 14:00 WW1 3:00 Deshuttering 8:00 WW7 1:30 Outer shutter 0:30 Reinforcement cage 10:45 OPG4 2:45 OPG3 0:30 Fixing Bulkhead 1:30 Fixing Bulkhead 1:30 Fixing Bulkhead 0:15 DW2 2:15 Profiling 2:00 OPG6 4:30 Inner 2:30 WW3 1:00 NVAT2 3:00 WW3 1:30 Concreting 5:30 NVAT1 18:30 NVAT1 18:30 NVAT1 3:00 WW1 3:00 Deshuttering 0:40 WW7 2:15 Outer shutter 1:00 DW5 0:45 Reinforcement cage 1:50 Profiling 1:25
S5U(M) 16 4:00 AM 5:50 AM 1:50 Profiling	
5:50 AM 7:15 AM 1:25 Inner	
7:15 AM 8:00 AM 0:45 WW3	
8:00 AM 11:00 AM 3:00 Concreting	

Waste	Reasons
rubic	Iteasons

Waste Type	Waste Code	Waste Reason				
Defective Waste	DW1	Wrong dimension given to labor of locator fixing				
	DW2	Profile pipe is not welded at given dimension				
	DW3	Defect in RMC plant, silo making noise				
	DW4	Reinforcement cage was not ready due to missing some bars in godown				
	DW6	Reinforcement cage having some defect				
	DW5	Disputed in reinforcement cage				
Inventory Waste	IW1	Not enough workers, lack of labors				
Non-value added time	NVAT1	Deshuttering strength time				
	NVAT2	Lunch or Dinner				
Over Processing	OPG1	Consultant checking & Rework				
	OPG2	Bringing inner after deshuttering previous from another bay/bed				
	OPG3	Have to bring inner from other bay which consume more time				
	OPG4	Have to bring bulkhead from other bay which consume more time				
	OPG5	Change measurements of grip and locator in bulkhead				
	OPG6	Gathering missing parts of inner				
Waiting Waste	WW1	Not started further work				
	WW2	Miscellaneous				
	WW3	Waiting for transit mixer & boom placer				
	WW4	Working somewhere else				
	WW5	"U" missing for starting profiling				
	WW6	Laziness				
	WW7	Doing nothing				



Data Analysis

Segment Casting Data-01 Bar Chart of Segment Data-01

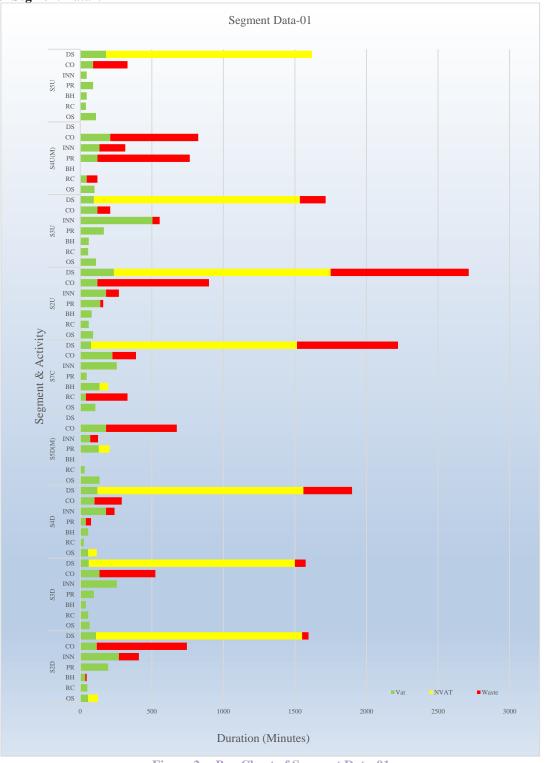
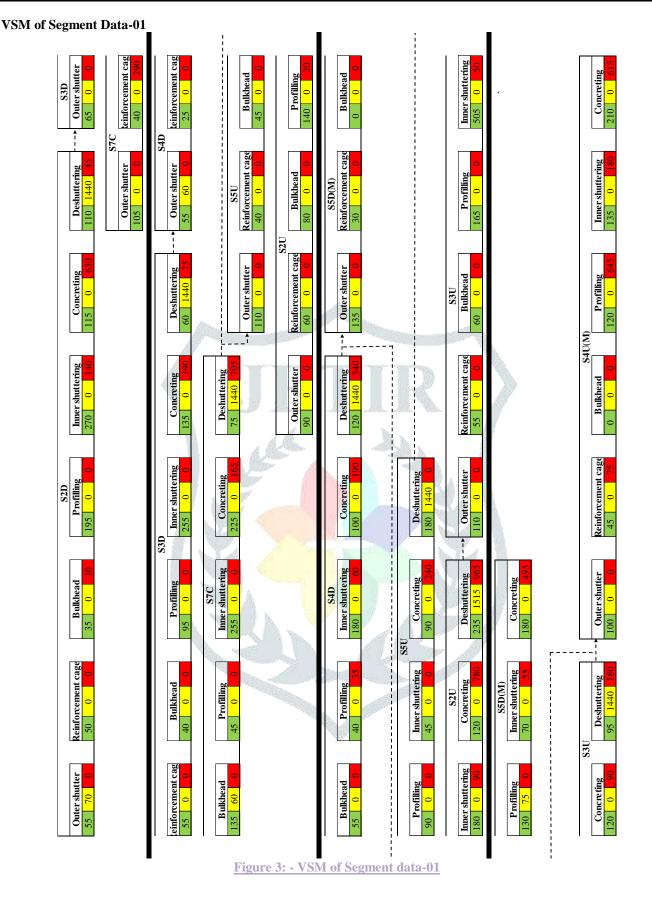
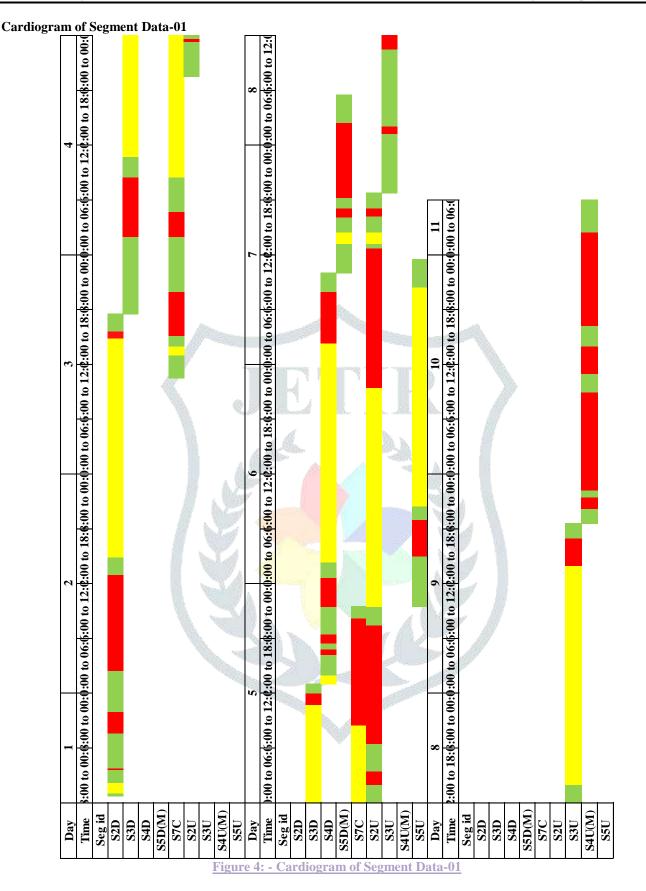


Figure 2: - Bar Chart of Segment Data-01





Analysis of Segment Data-01 Table 1: - Analysis of Segment Data-01

	Activit	y Time (s)		_	Activity Time (%)			
Act.	VAT	NVAT	Waste	Total	VAT	NVAT	Waste	Total
OS	825	130	0	955	3.34%	0.53%	0.00%	3.86%
RC	400	0	365	765	1.62%	0.00%	1.48%	3.09%
BH	450	60	10	520	1.82%	0.24%	0.04%	2.10%
PR	1020	75	700	1795	4.12%	0.30%	2.83%	7.26%
INN	1895	0	575	2470	7.66%	0.00%	2.32%	9.99%
CO	1295	0	3595	4890	5.24%	0.00%	14.53%	19.77%
DS	875	10155	2310	13340	3.54%	41.06%	9.34%	53.93%
Total	6760	10420	7555	24735	27.33%	42.13%	30.54%	100%

As shown in above table, maximum waste consuming activity in all segment casting is concreting activity (CO), 14.53% (3595m). This happens due to previous activity always scheduled as concreting activity comes in night and at night boom placer and transit mixer both major machineries were busy at site in casting because casting at site is not possible in day time due to high vehicular and pedestrian traffic.

Second highest waste consuming activity was deshuttering (DS), 9.34% (2310m) due to postponed of the deshuttering work because of improper information follow between involved authorities for deshuttering execution order and also delay in their self-initiation.

Beside former, Profiling (PR) and fixing inner shuttering (INN) for segments were equally waste consuming activity and its waste are as 2.83% (700m) and 2.32% (575m) simultaneously. Reason behind above waste is that, inner have problem of gathering parts & assembling and miscellaneous working; profiling consume large time in error of dimension of welded profile pipe.

So over all for segment casting at casting yard for one span of bridge construction, having 27.33% (6760m) productive time; 42.13% (10420m) non-value added time & 30.53% (7555m) waste time.



Segment Casting Data-02

Bar Chart of Segment Data-02

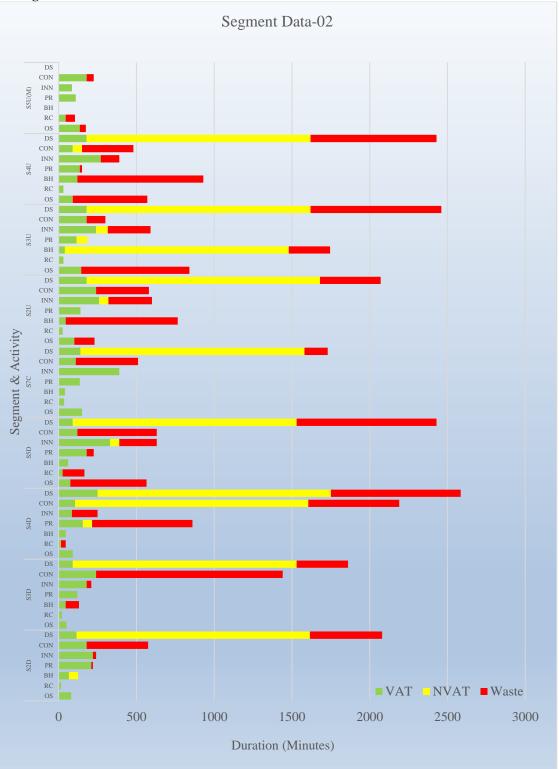
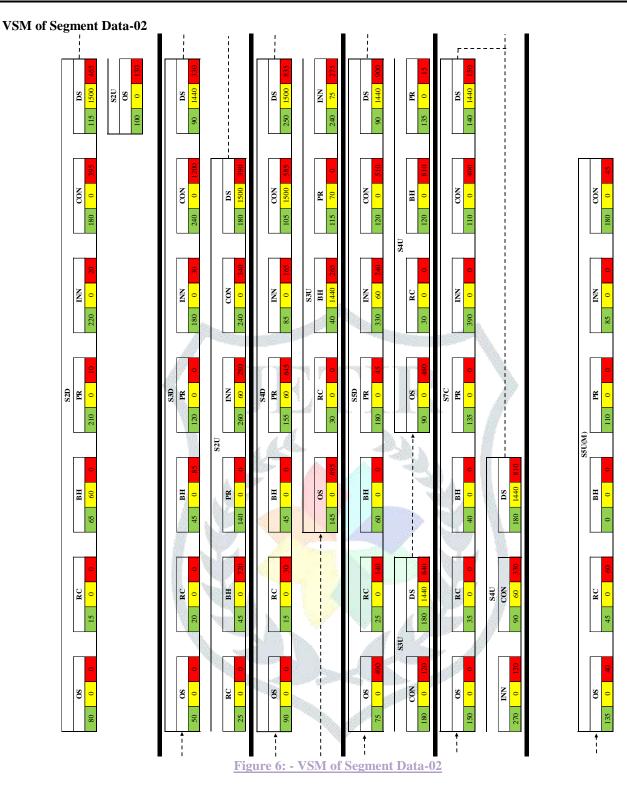
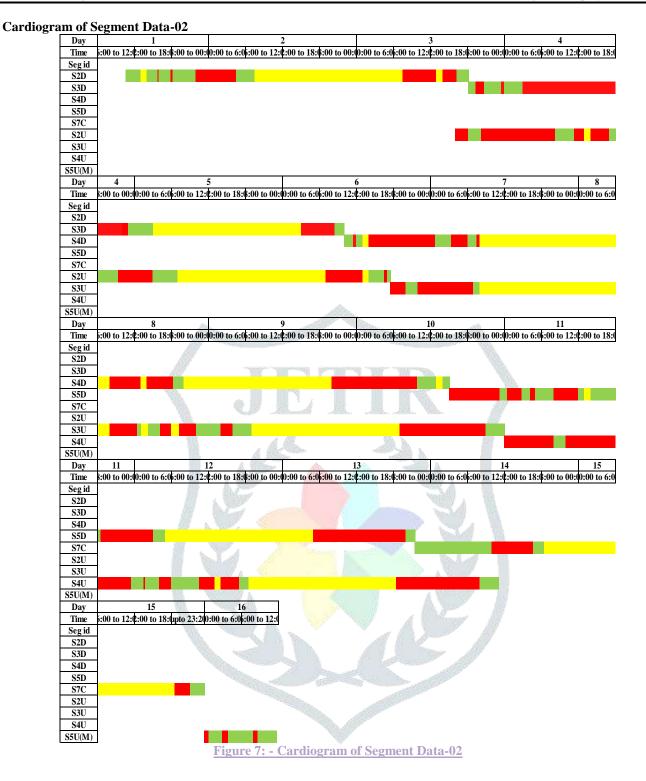


Figure 5: - Bar Chart of Segment Data-02





Analysis of Segment Data-02 <u>Table 2: - Analysis of Segment Data-02</u>

	Activity Time (s)				Activity Time (%)			
Act.	VAT	NVAT	Waste	Total	VAT	NVAT	Waste	Total
OS	33%	0%	67%	2750	2.46%	0.00%	4.94%	7.40%
RC	51%	0%	49%	470	0.65%	0.00%	0.62%	1.26%
BH	12%	39%	49%	3840	1.24%	4.04%	5.06%	10.33%
PR	61%	6%	33%	2145	3.50%	0.35%	1.92%	5.77%
INN	61%	6%	33%	3385	5.54%	0.52%	3.04%	9.11%
CON	21%	23%	57%	6930	3.89%	4.20%	10.56%	18.65%

DS 7% 66% 27% 17645 3.30% 31.48% 12.70% 47.48%		5% 20% 45% 37165 20.57		
	DS	% 66% 27% 17645 3.30%	6 31.48% 12.70% 47.489	%

As shown in above table, maximum waste consuming activity in all segment casting is deshuttering (DS), 12.70% (4720m) due to postponed of the deshuttering work because of improper information follow between involved authorities for deshuttering execution order and also delay in their self-initiation.

Second highest waste consuming activity is concreting activity, 10.56% (3925m). This happens due to previous activity always scheduled as concreting activity comes in night and at night boom placer and transit mixer both major machineries were busy in site casting because casting at site is not possible in day due to high vehicle and pedestal traffic.

Other major waste consuming activities are fixing bulkhead, fixing outer shutter and fixing inner shuttering, having waste of 5.06% (1880m), 4.94% (1835m) and 3.04% (1130m) simultaneously. In bulkhead and inner having same reason that same id segment casting parallel in two bed in same bay, causes mismanaging of part/lack of material and consume more time for arranging/making/bringing proper material. And in outer shutter, work not started due to lack of labor.

So over all for segment casting at casting yard for one span of bridge construction, having 20.57% (7645m) productive time; 40.29% (15085m) non-value added time & 38.84% (14435m) waste time.

Comparison between Segment Data-01 & Segment Data-02

As shown in both segment casting data,

- Effective productive time is 6760 & 7645m simultaneously, which is almost same to each other still having deference in both production % having 20.57% & 27.33% of total segment casting of one span of bridge.
- Concreting activity consumes 14.53% (3595m) & 10.56% (3925m) waste simultaneously.
- Deshuttering consumes 9.34% (2310m) & 12.70% (4720m) waste simultaneously.
- Inserting reinforcement cage activity non-value added time is 6.38% (4250s) & 5.64% (3240s).
- Waste time is also occurring in all activities except 1st data's outer shuttering and bulkhead fixing, rest having more than 4 hours in both the segment casting case at casting yard.

Conclusion

- Highest waste time consuming in defective waste like rework in reinforcement cage, profile pipe is not welded as per dimension or dimension is not given properly.
- Second thing is waiting waste consume more waste time in waiting for transit mixer or boom placer.
- Third waste which consume more time is over-processing or excess processes like inner parts are misplaced causes excess time for gathering at one place and all same segment id has been casted on all bed of same bay which causes excess time for bringing parts from other bay.

Recommendation

- From aligning first segment of the span to concreting its last segment, all processes are repetitive as production factory, so ideal use of machinery, trained workers and proper use of material reduce the waiting waste by stopping the deviation and breakage.
- Use suitable equipment like hopper or something for segment concreting at night. Proper communication or alertness of authorized person for deshuttering after getting deshuttering strength.
- Reinforcement cage and profiling need to supervised and checked for 2-3 times in while working to reduce defective waste.

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