

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

| Seg. Id | Day | Time(hh:mm) | | Dur. (m) | Activity |
|---------|-----|-------------|----------|--------------|------------------------------|
| | | Start | End | | |
| S2D | 1 | 12:45 PM | 1:05 PM | 0:20 | Outer shutter |
| | | 1:05 PM | 2:15 PM | 1:10 | NVAT2 |
| | | 2:15 PM | 2:50 PM | 0:35 | Outer shutter |
| | | 2:50 PM | 3:40 PM | 0:50 | Inserting Reinforcement cage |
| | | 3:40 PM | 3:50 PM | 0:10 | OPG5 |
| | | 3:50 PM | 4:25 PM | 0:35 | Fixing bulkhead |
| | | 4:25 PM | 7:40 PM | 3:15 | Profiling |
| | | 7:40 PM | 10:00 PM | 2:20 | OPG2 |
| | | 10:00 PM | 12:00 AM | 2:00 | Inner |
| | 2 | 12:00 AM | 2:30 AM | 2:30 | Inner |
| | | 2:30 AM | 1:00 PM | 10:30 | WW3 |
| | | 1:00 PM | 2:55 PM | 1:55 | Concreting |
| | | 2:55 PM | 12:00 AM | 9:05 | NVAT1 |
| | 3 | 12:00 AM | 2:55 PM | 14:55 | NVAT1 |
| | | 2:55 PM | 3:40 PM | 0:45 | WW1 |
| 3:40 PM | | 5:30 PM | 1:50 | Deshuttering | |
| S3D | 3 | 5:30 PM | 6:35 PM | 1:05 | Outer shutter |
| | | 6:35 PM | 7:30 PM | 0:55 | Inserting Reinforcement cage |
| | | 7:30 PM | 8:10 PM | 0:40 | Fixing bulkhead |
| | | 8:10 PM | 9:45 PM | 1:35 | Profiling |
| | | 9:45 PM | 12:00 AM | 2:15 | Inner |
| | 4 | 12:00 AM | 2:00 AM | 2:00 | Inner |
| | | 2:00 AM | 8:30 AM | 6:30 | WW3 |
| | | 8:30 AM | 10:45 AM | 2:15 | Concreting |
| | | 10:45 AM | 12:00 AM | 13:15 | NVAT1 |
| | 5 | 12:00 AM | 10:45 AM | 10:45 | NVAT1 |
| | | 10:45 AM | 12:00 PM | 1:15 | WW1 |
| | | 12:00 PM | 1:00 PM | 1:00 | Deshuttering |
| | S4D | 5 | 1:00 PM | 2:00 PM | 1:00 |
| 2:00 PM | | | 2:55 PM | 0:55 | Outer shutter |
| 2:55 PM | | | 3:20 PM | 0:25 | Inserting Reinforcement cage |
| 3:20 PM | | | 4:15 PM | 0:55 | Fixing bulkhead |
| 4:15 PM | | | 4:50 PM | 0:35 | WW4 |
| 4:50 PM | | | 5:30 PM | 0:40 | Profiling |
| 5:30 PM | | | 6:30 PM | 1:00 | WW2 |
| 6:30 PM | | | 9:30 PM | 3:00 | Inner |
| 9:30 PM | | | 12:00 AM | 2:30 | WW3 |
| 6 | | 12:00 AM | 12:40 AM | 0:40 | WW3 |
| | | 12:40 AM | 2:20 AM | 1:40 | Concreting |

| | | | | | | |
|----------|----------|----------|----------|----------|------------------------------|---------------|
| | | 2:20 AM | 12:00 AM | 21:40 | NVAT1 | |
| | 7 | 12:00 AM | 2:20 AM | 2:20 | NVAT1 | |
| | | 2:20 AM | 8:00 AM | 5:40 | WW1 | |
| | | 8:00 AM | 10:00 AM | 2:00 | Deshuttering | |
| | | 10:00 AM | 12:15 PM | 2:15 | Outer shutter | |
| S5D(M) | 7 | 12:15 PM | 12:45 PM | 0:30 | Inserting Reinforcement cage | |
| | | 12:45 PM | 1:15 PM | 0:30 | Profiling | |
| | | 1:15 PM | 2:30 PM | 1:15 | NVAT2 | |
| | | 2:30 PM | 4:10 PM | 1:40 | Profiling | |
| | | 4:10 PM | 5:05 PM | 0:55 | OPG2 | |
| | | 5:05 PM | 6:15 PM | 1:10 | Inner | |
| | | 6:15 PM | 12:00 AM | 5:45 | WW3 | |
| | 8 | 12:00 AM | 2:30 AM | 2:30 | WW3 | |
| | | 2:30 AM | 5:30 AM | 3:00 | Concreting | |
| | | 5:30 AM | 12:00 AM | 18:30 | NVAT1 | |
| | 9 | 12:00 AM | 5:30 AM | 5:30 | NVAT1 | |
| | S7C | 3 | 10:30 AM | 12:15 PM | 1:45 | Outer shutter |
| 12:15 PM | | | 1:00 PM | 0:45 | Fixing bulkhead | |
| 1:00 PM | | | 2:00 PM | 1:00 | NVAT2 | |
| 2:00 PM | | | 3:10 PM | 1:10 | Fixing bulkhead | |
| 3:10 PM | | | 8:00 PM | 4:50 | DW4 | |
| 8:00 PM | | | 8:40 PM | 0:40 | Inserting Reinforcement cage | |
| 8:40 PM | | | 9:00 PM | 0:20 | Fixing bulkhead | |
| 9:00 PM | | | 9:45 PM | 0:45 | Profiling | |
| 4 | | 9:45 PM | 12:00 AM | 2:15 | Inner | |
| | | 12:00 AM | 2:00 AM | 2:00 | Inner | |
| | | 2:00 AM | 4:45 AM | 2:45 | WW3 | |
| | | 4:45 AM | 8:30 AM | 3:45 | Concreting | |
| 5 | | 8:30 AM | 12:00 AM | 15:30 | NVAT1 | |
| | | 12:00 AM | 8:30 AM | 8:30 | NVAT1 | |
| | | 8:30 AM | 8:15 PM | 11:45 | WW1 | |
| S2U | | 3 | 8:15 PM | 9:30 PM | 1:15 | Deshuttering |
| | | | 7:30 PM | 9:00 PM | 1:30 | Outer shutter |
| | 9:00 PM | | 10:00 PM | 1:00 | Inserting Reinforcement cage | |
| | 10:00 PM | | 11:20 PM | 1:20 | Fixing bulkhead | |
| | 11:20 PM | | 11:40 PM | 0:20 | WW5 | |
| | 4 | 11:40 PM | 12:00 AM | 0:20 | Profiling | |
| | | 12:00 AM | 2:00 AM | 2:00 | Profiling | |
| | | 2:00 AM | 3:30 AM | 1:30 | OPG6 | |
| | | 3:30 AM | 6:30 AM | 3:00 | Inner | |
| | | 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 | |

| | | | | | |
|----------|---------|----------|--------------|---------|------------------------------|
| | 5 | 12:00 AM | 9:30 PM | 21:30 | NVAT1 |
| | | 9:30 PM | 12:00 AM | 2:30 | WW1 |
| | 6 | 12:00 AM | 12:45 PM | 12:45 | WW1 |
| | | 12:45 PM | 1:15 PM | 0:30 | Deshuttering |
| | | 1:15 PM | 2:30 PM | 1:15 | NVAT2 |
| | | 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 | | |
| S3U | 7 | 6:45 PM | 8:35 PM | 1:50 | Outer shutter |
| | | 8:35 PM | 9:30 PM | 0:55 | Inserting Reinforcement cage |
| | | 9:30 PM | 10:30 PM | 1:00 | Fixing bulkhead |
| | | 10:30 PM | 12:00 AM | 1:30 | Profiling |
| | 8 | 12:00 AM | 1:15 AM | 1:15 | Profiling |
| | | 1:15 AM | 2:05 AM | 0:50 | OPG6 |
| | | 2:05 AM | 10:30 AM | 8:25 | Inner |
| | | 10:30 AM | 12:00 PM | 1:30 | WW3 |
| | | 12:00 PM | 2:00 PM | 2:00 | Concreting |
| | | 2:00 PM | 12:00 AM | 10:00 | NVAT1 |
| | 9 | 12:00 AM | 2:00 PM | 14:00 | NVAT1 |
| | | 2:00 PM | 5:00 PM | 3:00 | WW7 |
| | | 5:00 PM | 6:35 PM | 1:35 | Deshuttering |
| | S4U(M) | 9 | 6:35 PM | 8:15 PM | 1:40 |
| 8:15 PM | | | 9:30 PM | 1:15 | DW6 |
| 9:30 PM | | | 10:15 PM | 0:45 | Inserting Reinforcement cage |
| 10:15 PM | | | 12:00 AM | 1:45 | DW6 |
| 10 | | 12:00 AM | 9:00 AM | 9:00 | DW6 |
| | | 9:00 AM | 11:00 AM | 2:00 | Profiling |
| | | 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 | WW3 |
| | | 2:30 AM | 6:00 AM | 3:30 | Concreting |
| S5U | | 9:30 PM | 11:20 PM | 1:50 | Outer shutter |
| | | 11:20 PM | 12:00 AM | 0:40 | Inserting Reinforcement cage |
| | 6 | 12:00 AM | 12:45 AM | 0:45 | Fixing bulkhead |
| | | 12:45 AM | 2:15 AM | 1:30 | Profiling |
| | | 2:15 AM | 3:00 AM | 0:45 | Inner |
| | | 3:00 AM | 7:00 AM | 4:00 | WW3 |
| | | 7:00 AM | 8:30 AM | 1:30 | Concreting |
| | | 8:30 AM | 12:00 AM | 15:30 | NVAT1 |
| | 7 | 12:00 AM | 8:30 AM | 8:30 | NVAT1 |
| | | 8:30 AM | 11:30 AM | 3:00 | Deshuttering |

Segment Casting Data-02

| Seg. id | Day | Time | | Dur. (m) | Activity | |
|----------|---------|----------|----------|----------|--------------------|---------------|
| | | Start | End | | | |
| S2D | 1 | 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 | 2:15 PM | 0:15 | Fixing Bulkhead | |
| | | 2:15 PM | 3:45 PM | 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 | |
| | | 6:15 PM | 9:55 PM | 3:40 | Inner | |
| | 9:55 PM | 12:00 AM | 2:05 | WW3 | | |
| | 2 | 12:00 AM | 4:30 AM | 4:30 | WW3 | |
| | | 4:30 AM | 7:30 AM | 3:00 | Concreting | |
| | | 7:30 AM | 12:00 AM | 16:30 | NVAT1 | |
| | 3 | 12:00 AM | 7:30 AM | 7:30 | NVAT1 | |
| 7:30 AM | | 1:00 PM | 5:30 | WW1 | | |
| 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 | |
| S3D | 3 | 6:10 PM | 7:00 PM | 0:50 | Outer shutter | |
| | | 7:00 PM | 7:20 PM | 0:20 | Reinforcement cage | |
| | | 7:20 PM | 8:45 PM | 1:25 | WW4 | |
| | | 8:45 PM | 9:30 PM | 0:45 | Fixing Bulkhead | |
| | | 9:30 PM | 11:30 PM | 2:00 | Profiling | |
| | | 11:30 PM | 12:00 AM | 0:30 | WW7 | |
| | 4 | 12:00 AM | 3:00 AM | 3:00 | Inner | |
| | | 3:00 AM | 8:00 PM | 17:00 | OPG1 | |
| | | 8:00 PM | 10:00 PM | 2:00 | WW2 | |
| | | 10:00 PM | 11:00 PM | 1:00 | WW3 | |
| | | 11:00 PM | 12:00 AM | 1:00 | Concreting | |
| | 5 | 12:00 AM | 3:00 AM | 3:00 | Concreting | |
| | | 3:00 AM | 12:00 AM | 21:00 | NVAT1 | |
| | 6 | 12:00 AM | 3:00 AM | 3:00 | NVAT1 | |
| | | 3:00 AM | 8:30 AM | 5:30 | WW1 | |
| | | 8:30 AM | 10:00 AM | 1:30 | Deshuttering | |
| | S4D | 6 | 10:00 AM | 11:30 AM | 1:30 | Outer shutter |
| | | | 11:30 AM | 12:00 PM | 0:30 | DW4 |
| 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 |
| | 7 | 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 |
| | | 6:05 AM | 7:30 AM | 1:25 | Inner |
| | | 7:30 AM | 8:00 AM | 0:30 | OPG1 |
| | | 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 |
| | 9 | 8:00 PM | 12:00 AM | 4:00 | NVAT1 |
| | | 12:00 AM | 8:00 PM | 20:00 | NVAT1 |
| | 10 | 8:00 PM | 12:00 AM | 4:00 | WW1 |
| | | 12:00 AM | 9:55 AM | 9:55 | WW1 |
| | | 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 |
| S5D | 10 | 3:05 PM | 11:15 PM | 8:10 | WW7 |
| | | 11:15 PM | 12:00 AM | 0:45 | Outer shutter |
| | 11 | 12:00 AM | 12:30 AM | 0:30 | 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 | 0:45 | DW6 |
| | | 5:00 AM | 8:00 AM | 3:00 | Profiling |
| | | 8:00 AM | 12:00 PM | 4:00 | OPG6 |
| | | 12:00 PM | 1:00 PM | 1:00 | Inner |
| | | 1:00 PM | 2:00 PM | 1:00 | NVAT2 |
| | | 2:00 PM | 6:30 PM | 4:30 | Inner |
| | 6:30 PM | 12:00 AM | 5:30 | WW3 | |
| | 12 | 12:00 AM | 3:00 AM | 3:00 | WW3 |
| | | 3:00 AM | 5:00 AM | 2:00 | Concreting |
| | | 5:00 AM | 12:00 AM | 19:00 | NVAT1 |
| | 13 | 12:00 AM | 5:00 AM | 5:00 | NVAT1 |
| | | 5:00 AM | 8:00 PM | 15:00 | WW1 |
| | | 8:00 PM | 9:30 PM | 1:30 | Deshuttering |
| S7C | 13 | 9:30 PM | 12:00 AM | 2:30 | Outer shutter |
| | 14 | 12:00 AM | 2:45 AM | 2:45 | Inner |
| | | 2:45 AM | 3:20 AM | 0:35 | Reinforcement cage |
| | | 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 | |
| | 15 | 12:00 AM | 4:40 PM | 16:40 | NVAT1 | |
| | | 4:40 PM | 9:00 PM | 4:20 | WW1 | |
| | | 9:00 PM | 11:20 PM | 2:20 | Deshuttering | |
| | S2U | 3 | 4:00 PM | 6:10 PM | 2:10 | WW7 |
| | | | 6:10 PM | 7:50 PM | 1:40 | Outer shutter |
| 7:50 PM | | | 8:15 PM | 0:25 | Reinforcement cage | |
| 8:15 PM | | | 12:00 AM | 3:45 | OPG5 | |
| 4 | | 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 | |
| | | 11:20 AM | 1:00 PM | 1:40 | OPG1 | |
| | | 1:00 PM | 2:00 PM | 1:00 | NVAT2 | |
| | | 2:00 PM | 5:00 PM | 3:00 | WW7 | |
| | | 5:00 PM | 9:20 PM | 4:20 | Inner | |
| 5 | | 9:20 PM | 12:00 AM | 2:40 | WW3 | |
| | | 12:00 AM | 3:00 AM | 3:00 | DW3 | |
| | | 3:00 AM | 7:00 AM | 4:00 | Concreting | |
| 6 | | 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 | |
| | | 1:00 PM | 2:00 PM | 1:00 | NVAT2 | |
| | | 2:00 PM | 4:30 PM | 2:30 | Deshuttering | |
| S3U | | 6 | 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 |
| | | | 8:00 PM | 9:55 PM | 1:55 | Outer shutter |
| | | 7 | 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 | |
| | 7:00 AM | | 7:30 AM | 0:30 | Outer shutter | |
| | 8 | 7:30 AM | 8:00 AM | 0:30 | Reinforcement cage | |
| | | 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 | | |
| 10:45 AM | | 12:25 PM | 1:40 | IW1 | | |
| 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 | |
| | 9 | 12:00 AM | 2:00 AM | 2:00 | Inner | |
| | | 2:00 AM | 4:00 AM | 2:00 | WW3 | |
| | | 4:00 AM | 7:00 AM | 3:00 | Concreting | |
| | | 7:00 AM | 12:00 AM | 17:00 | NVAT1 | |
| | 10 | 12:00 AM | 7:00 AM | 7:00 | NVAT1 | |
| | | 7:00 AM | 9:00 PM | 14:00 | WW1 | |
| | | 9:00 PM | 12:00 AM | 3:00 | Deshuttering | |
| | S4U | 11 | 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 | |
| 11:30 PM | | | 12:00 AM | 0:30 | Fixing Bulkhead | |
| 12 | | 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 | |
| | | 4:00 AM | 6:00 AM | 2:00 | OPG6 | |
| | | 6:00 AM | 10:30 AM | 4:30 | Inner | |
| | | 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 | |
| | | 5:00 PM | 6:30 PM | 1:30 | Concreting | |
| | | 6:30 PM | 12:00 AM | 5:30 | NVAT1 | |
| 13 | | 12:00 AM | 6:30 PM | 18:30 | NVAT1 | |
| | | 6:30 PM | 12:00 AM | 5:30 | WW1 | |
| 14 | | 12:00 AM | 8:00 AM | 8:00 | WW1 | |
| | | 8:00 AM | 11:00 AM | 3:00 | Deshuttering | |
| S5U(M) | | 15 | 11:20 PM | 12:00 AM | 0:40 | WW7 |
| | | 16 | 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 |
| | 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

| 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

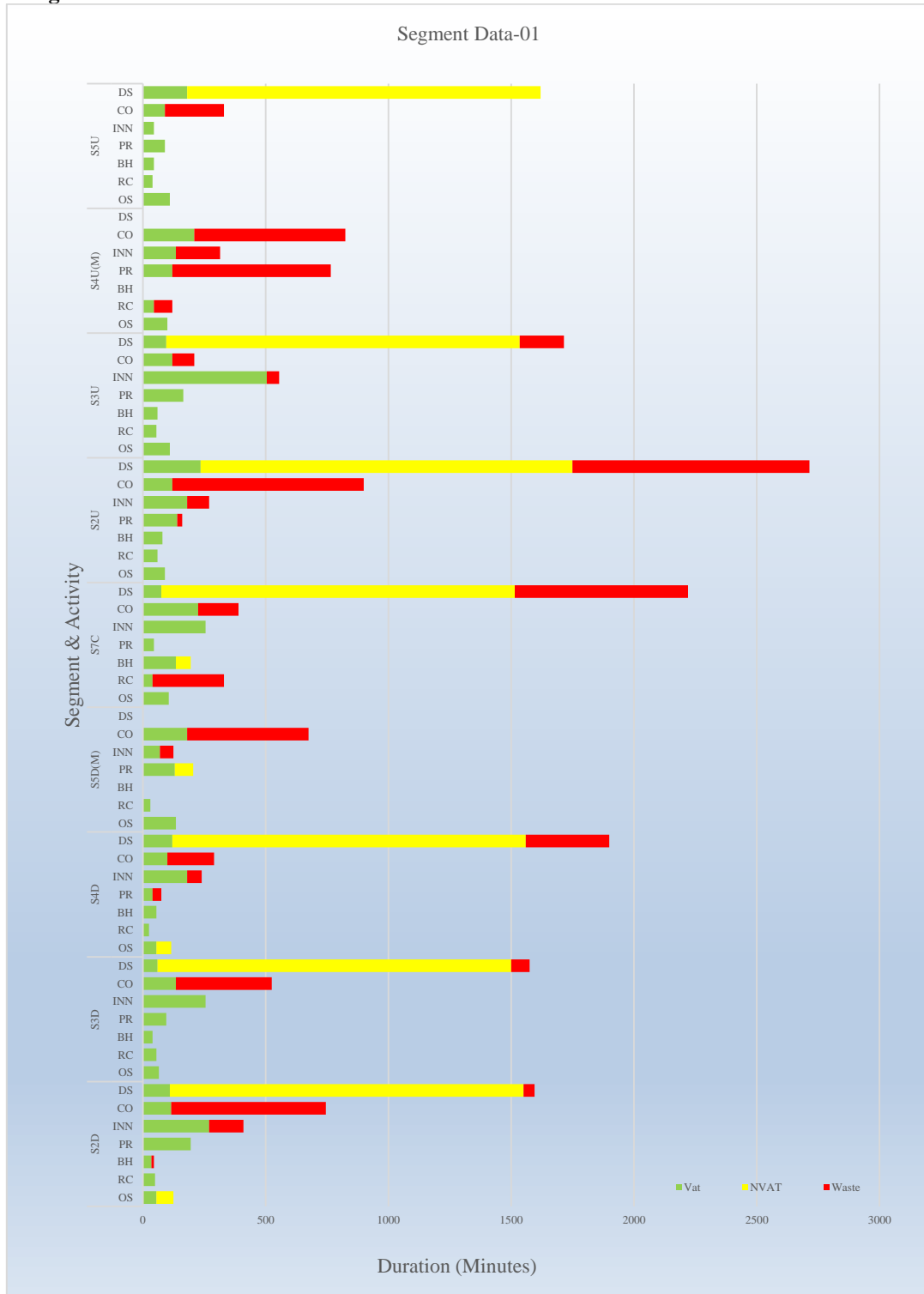


Figure 2: - Bar Chart of Segment Data-01

VSM of Segment Data-01

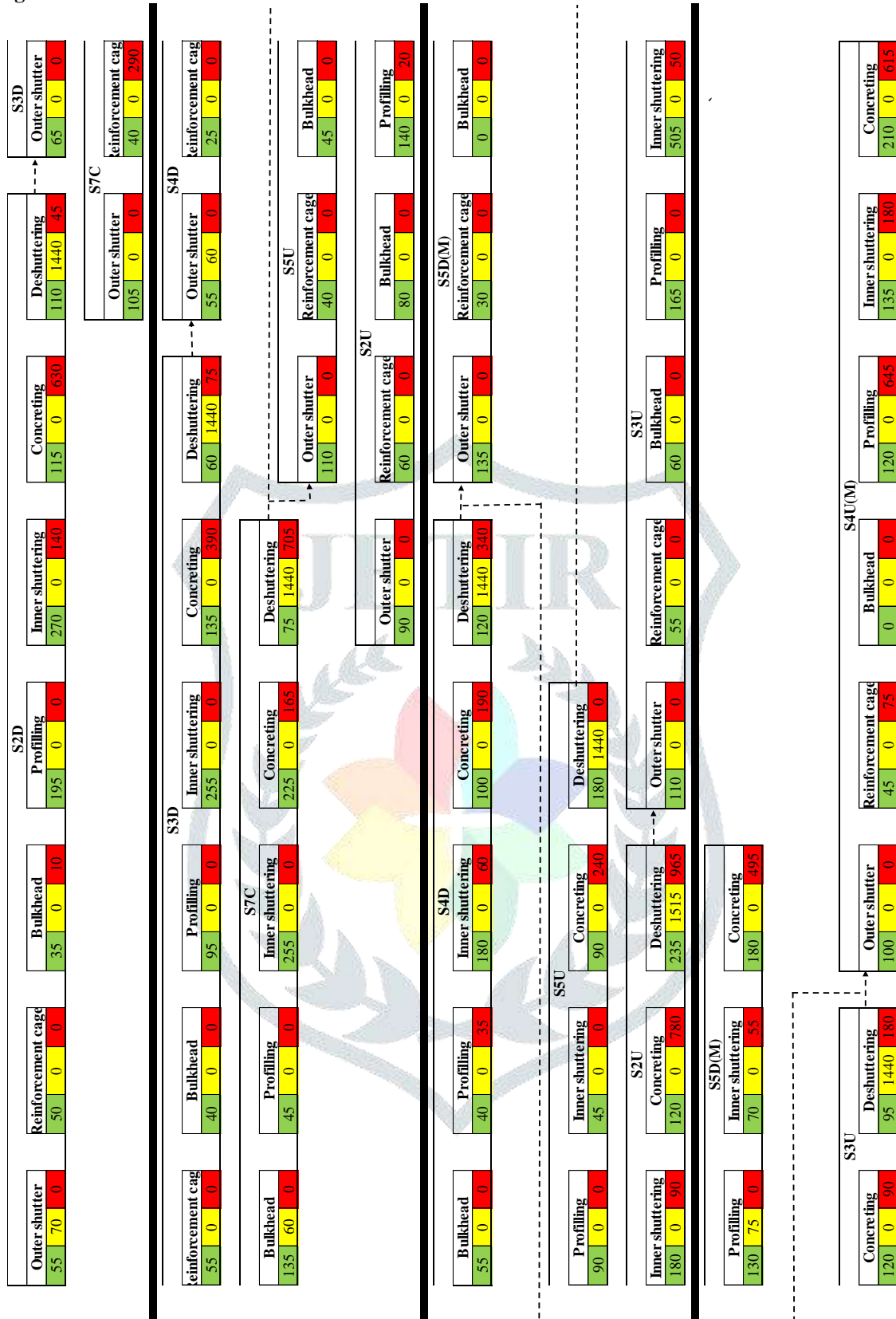


Figure 3: - VSM of Segment data-01

Cardiogram of Segment Data-01

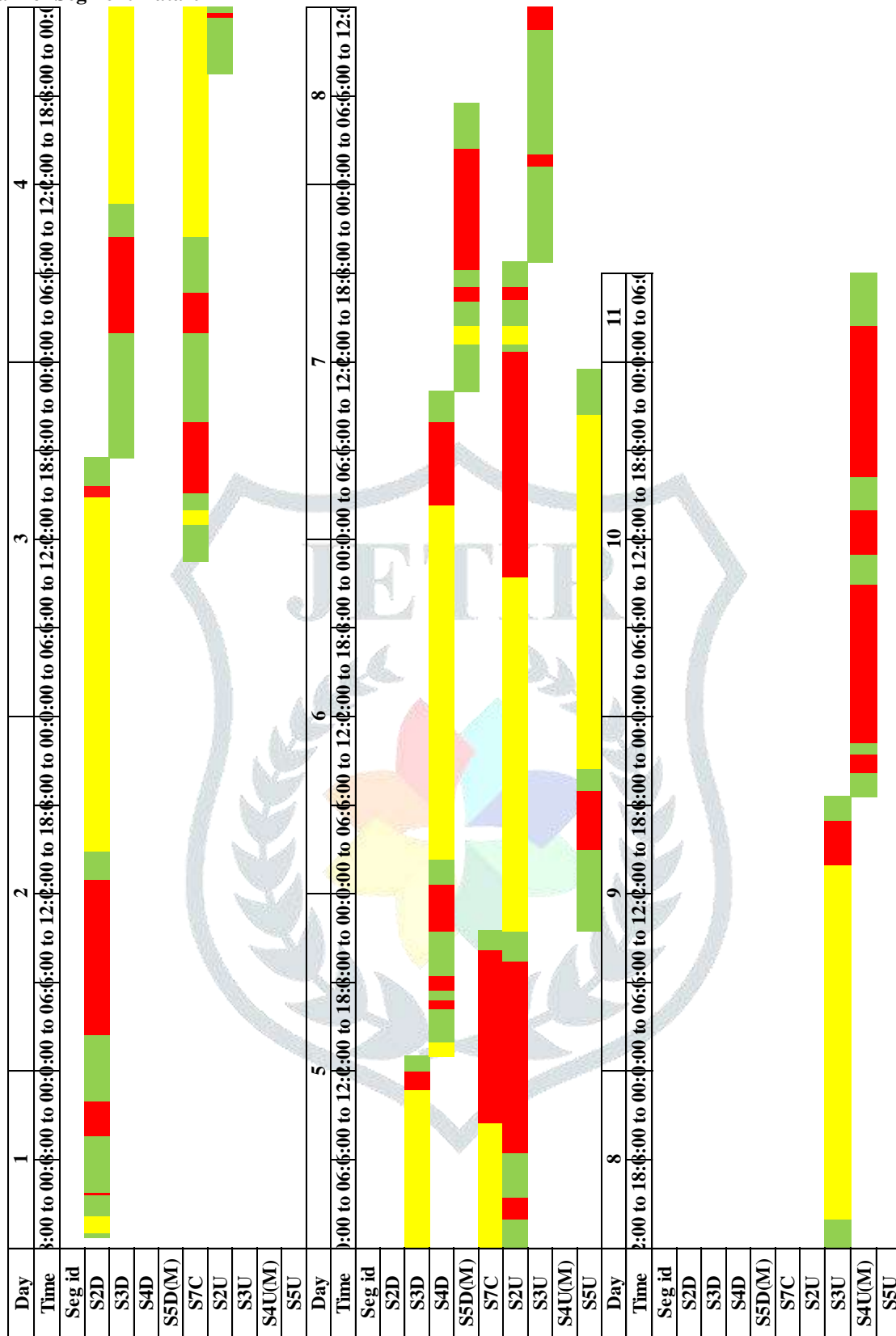


Figure 4: - Cardiogram of Segment Data-01

Analysis of Segment Data-01

Table 1: - Analysis of Segment Data-01

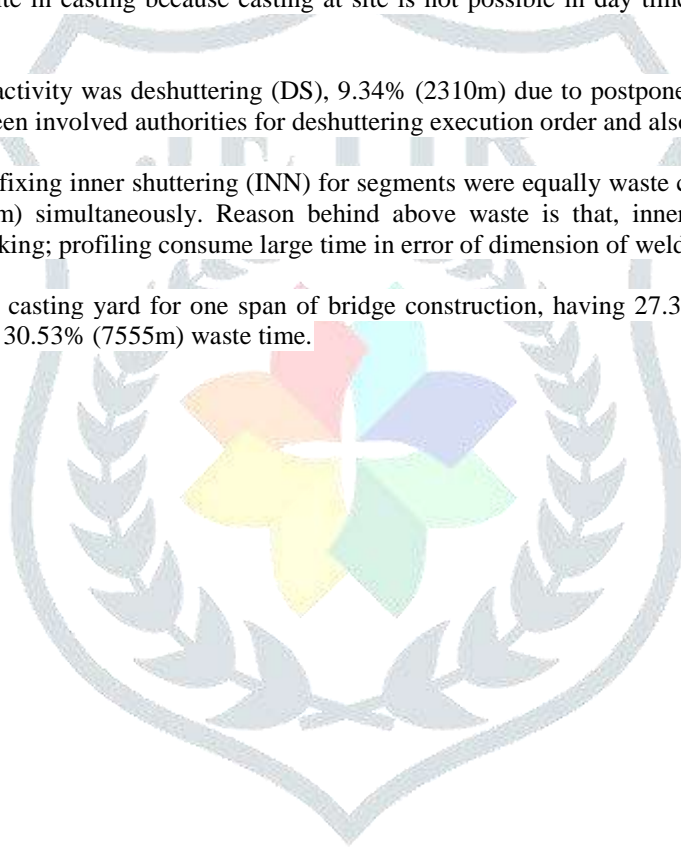
| Act. | Activity Time (s) | | | | Activity Time (%) | | | |
|--------------|-------------------|--------------|-------------|--------------|-------------------|---------------|---------------|-------------|
| | VAT | NVAT | Waste | Total | VAT | NVAT | Waste | Total |
| OS | 825 | 130 | 0 | 955 | 3.34% | 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

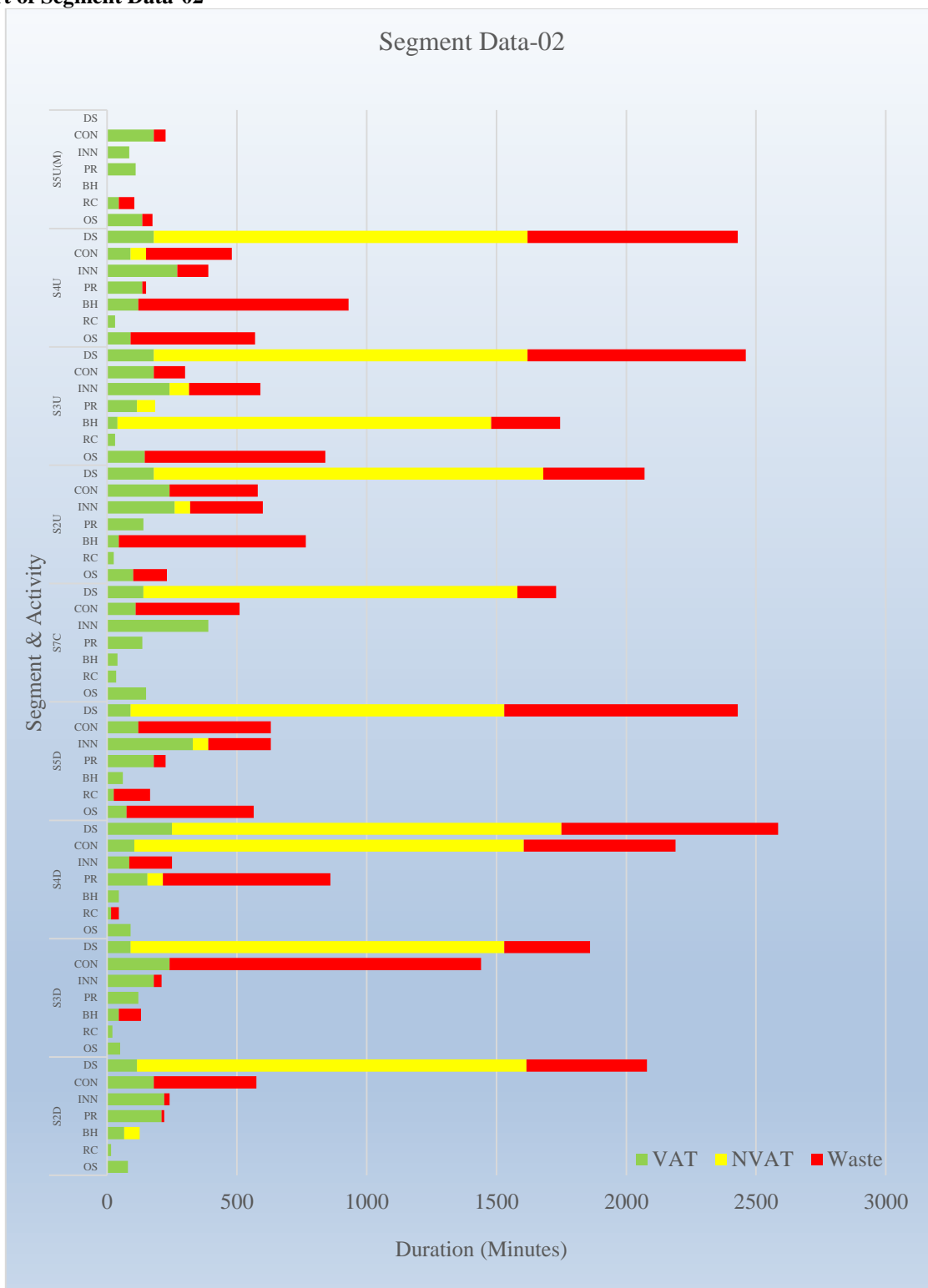


Figure 5: - Bar Chart of Segment Data-02

VSM of Segment Data-02



Figure 6: - VSM of Segment Data-02

Cardiogram of Segment Data-02

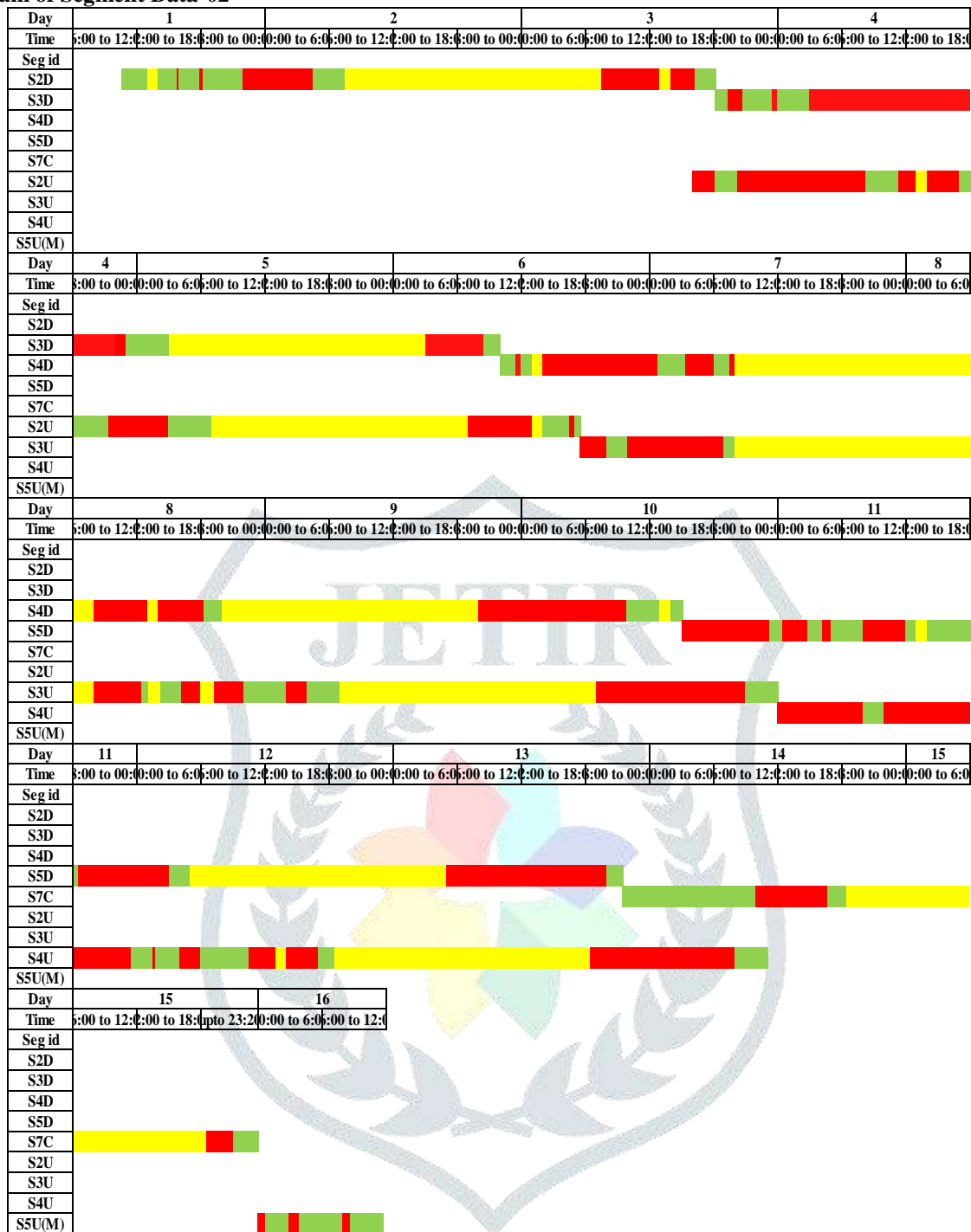


Figure 7: - Cardiogram of Segment Data-02

Analysis of Segment Data-02

Table 2: - Analysis of Segment Data-02

| Act. | Activity Time (s) | | | | Activity Time (%) | | | |
|------|-------------------|------|-------|-------|-------------------|-------|--------|--------|
| | 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% |
| Total | 35% | 20% | 45% | 37165 | 20.57% | 40.59% | 38.84% | 100% |

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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