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Effective Techniques for Time & Cost Reduction in Cellular Ground Base Tower & Their Supply Chain Management

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Abstract - *This project main aims to reduce the cost & time of construction & supply chain management of ground base cellular tower using replacement method over conventional method. As per research, conventional method required heavy machineries, large man power, materials also conventional method is time consuming & cost incurred method. In this project unnecessary steel sections in superstructure is replaced with Glass Fiber reinforced polymer & in supply chain management process used VTS Technique & Safety stock method for cost & time reduction for overall construction & supply chain management of ground base cellular tower.*

Key Words: Reduction of Construction cost, Reduction of Construction time, Replacement method.

1. INTRODUCTION

India has most progressive Country. In last few decades use of mobile phones is increased correspondently increase the cellular towers. Now a day; in India around 72% peoples used mobile phones. So it's increase the construction of cellular towers. Construction process of ground base cellular tower is site selection, site cleaning, site layout, pit excavation, plain cement concrete work, Reinforced cement concrete work, curing, backfilling, tower erection, electrification & last is site handed over to customer (Ref.Fig.1).

In supply chain management it helps to store the construction materials & Transport the materials in warehouse to site. The main purpose of supply chain management is to reduce inventory, increase the transaction speed with real-time exchange the data & fulfil the customer demands with more efficiently. But in conventional method construction of cellular tower superstructure used Rolled steel sections (Ref.Fig.2).

It is so heavy to installation so required heavy machineries, difficult to transport, high maintenance cost, susceptible to corrosion, length of steel is limited & durability is low. In conventional method of supply chain management in organization used Just in time method for inventory control & But Conventional method in supply chain management is so lengthy & time consuming process.

Fig -1: Ground Base Cellular

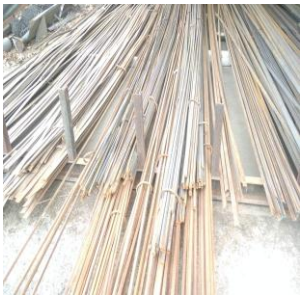

Fig -2: Steel Rods

In Just in time method, we were facing lack of inventory stock in warehouse that's why delay for construction then organization faced to penalty charges & extra man power (labor) charges. In Conventional method of transportation process; issues noted like late construction material delivery in site as well as extra cost incurred for labors. So Supply chain management process is directly affected on time & cost of overall cellular tower construction.

So main aim of this project is to reduce the overall time & cost of the construction of ground base cellular tower. In this project we use solutions over conventional method for time & cost reductions in construction of ground base cellular tower.

2. METHODOLOGY

2.1 Data Collection for Ground base cellular tower:

Data collection is the primary stage of this project. It gives the details about cellular organization & their employees strength, total detailed requirement of construction sites like list of equipment's, list of labors, list of materials, measurement sheet, site layout plan, total inventory report, transportation receipts etc. This data helps to calculate overall estimation of ground base cellular tower construction. Its helps to evaluate the total quantity, time & cost of the overall cellular tower construction. This audit work carried for kharadi, pune site. Following Table no.1 shows about cellular tower construction site like site name, height of tower, steps of constructions, transportation type etc.

Table -1: Audit Report

Details of Ground base Cellular tower	
Site Name	Kharadi, Pune.
Circle	Maharashtra & Goa
Build Vendor	Pragati
Excavation	C1 Stage
Tower Foundation Work	C2 Stage
Earthing	C3 stage
Type of Earthing	Chemical
Tower Erection	T1 Stage
Electrical	E1 Stage
Compound & Boundary wall	C4 Stage
Warehouse	Available
Site Tower Type	GBT
Height of Tower	24M
Types of Equipment's	JCB, Derrick Movement machine, Truck, Tracker.
Manpower	Available
Transportation type	By Road
Site Supervisor	Available

2.2 Questionnaire Survey for Problem Detection

Questionnaire Survey is very important step in this report. In Research method; studied on such different factors on construction & supply chain management and then select six important factors for making questionnaires for detect the issues in overall process. six important factors like Lack of Trust, Lack of Information Sharing, Lack of Inventory Arrangement & Transportation, Lack of Co-ordination, Lack of Fund & Construction Delay. Distribute questionaries' in cellular tower industries for using field research & Prepare questionnaires as per Likert's Five-point scale from 1 (Strongly Disagree) to 5 (Strongly agree). Following table no.2 shows the details of questionnaires Distribution.

Table -2: Details of Questionnaires Distribution

Total Number of Employees	Total Number of questionnaires Distribution
3242	2603

2.3 Interpretation of survey report

As per distribution of Questionnaires survey, Gather 110 responses from respondent. Questionnaires solve by using RII (Relative important index) method shows given below:

$$RII=\sum W/A*N$$

Where,

W is the weighting given to each factor by the respondents (ranging from 1 to 5),

A is the highest weight (i.e. 5 in this case)

N is the total number of respondents

$\sum W$ is the $5n_5+4n_4+3n_3+2n_2+1n_1$

As per RII method; Detect the issues in construction cost incurred & delay process & lack of inventory & Transportation process. (Ref. Table no.3).

Sr. No.	Factors	RII
1	Lack of Trust	0.46
2	Lack of Information Sharing	0.58
3	Lack of Inventory Arrangements & Transportations	0.67
4	Lack of Co-ordination	0.58
5	Lack of Funds	0.62
6	Construction Delay	0.75

Table -3: Details of Survey Report

Following Chart shows the detailed issues in Construction & Supply chain management process

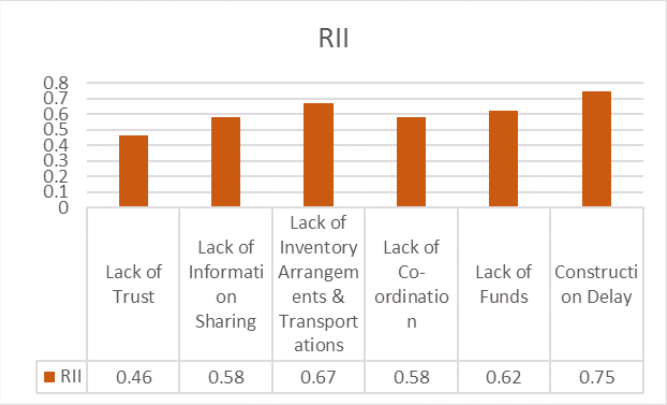

Chart -1: RII Survey Report Chart

2.4 Conventional method

As per Interpretation of survey report main issues found in following sections: -

i. Construction Cost incurred & Delay

ii. Lack of Inventory Control & Delay in Transportation Process

i. Construction Cost incurred & Delay

As per drawing, required 24M ground base square cellular tower in kharadi, pune. With able to support the antennas loading. The tower has been designed for soft soil with safe bearing capacity of 15 T/m^2, Type of foundation is Raft (as per soil bearing capacity). Factor of Safety is 1.5N/mm^2, Terrain Category is 1. The back filling done by proper compaction of soil in layers & it is necessary to done before erection of tower. Steel material used for construction of superstructure for ground base tower in conventional method. Activity of construction Site Cleaning & Site

Levelling, Soil bearing Testing, Drawing Selection Process, Layout, Pit Excavation, PCC Marking & PCC Bed, RCC Work, Curing, Backfilling, Earthing, Erection of Super Infra Steel Section, Installed passive equipment's, Electrification Work. Following fig. nos. (3 to 10) shows the construction activities.

Fig -3: Excavation

Fig -4: Material Availability

Fig -5: PCC

Fig -6: PCC Bed

Fig -7: BBS

Fig -8: RCC

Fig -9: Curing

Fig -10: Backfilling

ii. Lack of Inventory Control & Delay in Transportation Process

In Inventory control & management process Just in time method used in warehouse. In Just in Time method Purchase material from third party & directly shipped on construction sites but in this method facing problems like construction work is on hold because of material delay or unavailability. So its influencing on total cost of the project like cost incurred on labour without work, delay on project completion also Customer charged penalty by organization. The maximum turn around time (TAT) of Ground base tower construction is 21 days but in this site, work completion is 32 days. (Ref. Table No.4)

In transportation process by using documentation method like check in & out time, receipts validation etc. This process is time consuming as well as increase the cost of the transportation.

Table -4: Total Duration of Construction process

Sr. No.	Activity	Actual Work Completion Days	Required Work Completion Days	Delay In Days
1	Site Cleaning & Site Leveling	2	1	**1**
2	Soil bearing Testing	3	1	**2**
3	Drawing Selection Process	2	1	**1**
4	Layout	1	1	**0**
5	Pit Excavation	3	1	**2**
6	PCC Marking & PCC Bed	2	1	**1**
7	RCC Work	4	2	**2**
8	Curing	2	7	-5
9	Backfilling	1	1	**0**

10	Earthing	2	1	**1**
11	Erection of Super infra Steel Section	3	1	**2**
12	Installed passive equipment's	3	1	**2**
13	Electrification Work	4	2	**2**
	Total	**32**	**21**	**11 days**

Following table no.5 shows total Quantity & cost of the overall project.

Table -5: Abstract sheet

Sr. No	Item Description	Unit	Quantity	Rate	Amount
1	Soil Survey & testing	Each	1	27500	27500
2	site Cleaning & levelling charges	Sq. Meter	1	2000	2000
3	Excavation in semi / soft rock excluding backfilling	Cum.	68	200	13600
4	Excavation in all types of soils including backfilling	Cum.	80	630	50400
5	PCC	Cum.	5.974	9400	56155.6
6	RCC	Cum.	19.356	11300	218722.8
7	Stone soling	Cum.	19.94	1236	24645.84
8	Shuttering	Sq. Meter	70	187	13090
9	Plastering	Sq. Meter	60	250	15000
10	Tor steel for foundation	Kilogram	2308.01	62.7	144712.2
11	Bricks	No's	2750	7	19250
12	Coats(paint)	Sq. Meter	140	47	6580
13	Trenching, ducting & backfilling	Meter	52	2000	104000
14	steel for superstructure	Kilogram	10811.2	158	1712730
15	Water charges	Each	3	4500	13500
16	Transportation charges	Each	-	-	300000
17	Fixing & levelling of Foundation bolts & tower templates	Meter	52	5500	286000
18	Cables	Meter	403	157	63280
19	GI Sheet	Sq. Meter	19.9	925	18407.5
20	GI Strips	Meter	80	32	2560
21	GI Pipes	Meter	48	318	15264
22	Electrical work & Equipment's	Each	27	567967	146592.6
23	GI Wire Reinforced	Meter	116	206	23967
24	Conduit – PVC	Meter	40	83	3320
25	Earthing, GI strip (25x6)	Meter	90	276	24849
26	Machine Hiring charges for Excavation – Capex	Hour	128	781	100000
27	JCB hiring charges for soil filling with supervision	Hour	16	1200	19200
28	Boring Charges for Rocky Soil - Maintenance Free Earthing for GBT (Per Pit)	Each	2	5800	11600
29	Welding including transportation for site specific requirement	Meter	2	500	1000
30	Epoxy Grouting per kg	Kilogram	1	1300	1300
31	Concrete Grouting below Tower base Plate.	Each	3	795	2385
32	Erection Charges, GBT	MT.	6.51	9000	58590
33	Site Acceptance Testing Services - Quality Audit - GBT Sites, QA Services	Each	6	3500	21000
				Amount	**3521201**
				Extra labor cost	**40300**
				Penalty Charges	**11000**
				Total Amount	**3572501**

2.5 Material Replacement & Review

In Conventional Method Total cost of tower is Rs. 35,72,501/- & total duration for completion is 32 days.so its need to reduce the cost & time of construction. So in this project conventional material (steel) replaced with Glass fiber reinforced polymer material. Testing done by following types of material for construction.

A. Carbon fiber Reinforced polymer (CFRP)

B. Glass fiber Reinforced Polymer (GFRP)

Table -6: Tensile Strength

Material	Ultimate Tensile Strength (Mpa)	Modulus of elasticity (Gpa)
GFRP	1307.5 to 1467.8	55.6 to 57.5
CFRP	1127.6 to 1195.1	86.9 to 86.7

Table -7: Compressive Strength

Material	Ultimate Compressive Strength (Mpa)	Modulus of elasticity (Gpa)
GFRP	743.4 to 995.5	41.5 to 40
CFRP	570.6 to 617.6	49.7 to 50

As per mechanical properties of material testing GFRP is better than the CFRP Material (Ref. Table no.6 & 7), so steel material replaced with the Glass fiber reinforced polymer material.

2.6 Replacement Method

i. Construction of Ground base cellular tower

As per mechanical properties its prove that Glass fiber reinforced polymer (GFRP) material is better than the steel material. In conventional method; Construction of super structure in ground base cellular tower is made by steel material but steel is costly, heavy, very susceptible to corrosion & hence to failure, oxidation & chemical corrosion is big issues in steel material. But strength of glass fiber reinforced polymer is more than the steel material. GFRP is lightweight, low installation cost, low maintenance cost, affordable, less transportation cost & economically efficient compare then the steel material (Ref.fig.11). Replaced all middle steel angles, bars & bracing with glass fiber reinforced polymer in construction of superstructure for 4 legged square base cellular tower Except corner four poles.

Fig -11: Glass fiber reinforced polymer bars

ii. Transportation with VTS Tracking & Inventory Management by Safety stock

In transportation process, vehicle tracking system is best solution over conventional method.it shows the automatic location of tracked vehicle & doesn't need the documental validation. Software helps to collect the data & exact picture of vehicle locations.it helps to reduce the frauds as well as reduce the extra labor cost. Vehicle tracking system (VTS) is very useful for reduce the time & cost.

In inventory management control safety stock is best solution over conventional method. Safety stock is to reduce the risk as well as reduce the extra incurred cost of the project.in this method always keeps extra inventory for avoiding the delay of the project work also reduce the penalty charges. Safety stock always helps; If in case sales are greater than planned and/or the supplier is unable to deliver the additional units at the expected time. In cell tower organization they have own warehouse so carrying cost is always zero.

Following table no. 9 shows Quantity & Cost of overall project by replacement method.

Table -9: Abstract Sheet

Sr. No.	Item Description	Unit	Quantity	Rate	Amount
1	Soil Survey & testing	Each	1	27500	27500
2	site Cleaning & levelling charges	Sq. Meter	1	2000	2000
3	Excavation in semi/soft rock excluding backfilling	Cum.	68	200	13600
4	Excavation in all types of soils including backfilling	Cum.	80	630	50400
5	PCC	Cum.	5.974	9400	56155.6
6	RCC	Cum.	19.356	11300	218723
7	Stone soling	Cum.	19.94	1236	24645.8
8	Shuttering	Sq. Meter	70	187	13090
9	Plastering	Sq. Meter	60	250	15000
10	Tor steel for foundation	Kilogram	2308.01	62.7	144712
11	Bricks	No's	2750	7	19250
12	Coats(paint)	Sq. Meter	140	47	6580

13	Trenching, ducting & backfilling	Meter	52	2000	104000
14	GFRP for superstructure	Kilogram	8481.4	145	1228291
15	Water charges	Each	3	4500	13500
16	Transportation charges	Each			250000
17	Fixing & levelling of Foundation bolts & tower templates	Meter	52	5500	286000
18	Cables	Meter	403	157	63280
19	GI Sheet	Sq. Meter	19.9	925	18407.5
20	GI Strips	Meter	80	32	2560
21	GI Pipes	Meter	48	318	15264
22	Electrical work & Equipment's	Each	27	56797	146593
23	GI Wire Reinforced Pipe	Meter	116	206	23967
24	Conduit - PVC	Meter	40	83	3320
25	Earthing, GI strip (25x6)	Meter	90	276	24849
26	Machine Hiring charges for Excavation	Hour	128	781	100000
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28	Boring Charges for Rocky Soil - Maintenance Free Earthing for GBT/RTT (Per Pit)	Each	2	5800	11600
29	Welding including transportation for site specific requirement	Meter	2	500	1000
30	Epoxy Grouting per kg -	Kilogram	1	1300	1300
31	Concrete Grouting below Tower base Plate.	Each	3	795	2385
32	Erection Charges, GBT	MT.	6.51	9000	58590
33	Site Acceptance Testing Services	Each	6	3500	21000
				Amount	**2986762**
				Extra labor cost	**4300**
				Penalty Charges	**0**
				Total Amount	**2991062**

Table -10: Duration Required by Replacement Method

Sr. No.	Activity	Duration Required (Days)
1	Site Cleaning & Site Leveling	1
2	Soil bearing Testing	1
3	Drawing Selection Process	1
4	Layout	1
5	Pit Excavation	1
6	PCC Marking & PCC Bed	1
7	RCC Work	2
8	Curing	7
9	Backfilling	1
10	Earthing	1
11	Erection of Super infra GFRP structure	1
12	Installed passive equipment's	1
13	Electrification Work	2
	Total	**21**

As per replacement method total cost of ground base cellular tower is Rs.29,91,062/- (twenty-nine lakhs ninety-one thousand sixty-two rupees). Excluding GST charges & total duration required for completion of cellular tower is 21 days.

3. COMPARATIVE STATEMENT

Comparative statement shows the difference between Conventional vis-à-vis replacement method. It shows difference between total cost & total duration of construction process including supply chain management. In conventional method total cost of overall cellular tower construction is Rs.3572501/- & In replacement method total cost is Rs.2991062/- Shows Total duration of completion in conventional method is 32 days & Total duration of completion in Replacement method is 21 days.

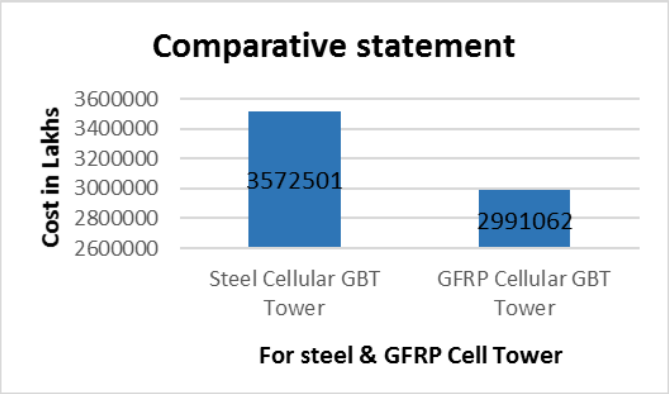

Fig -12: Comparative statement for construction cost

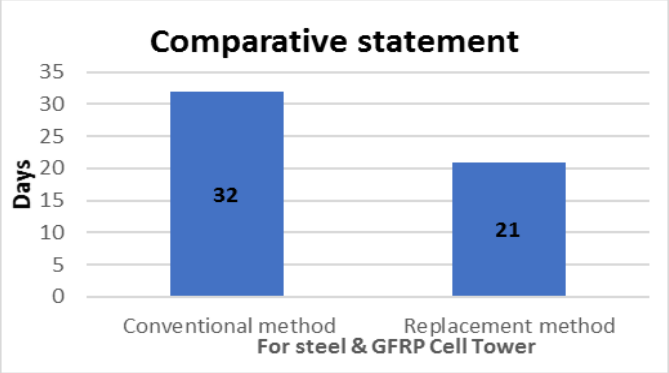

Fig -13: Comparative statement for construction time

4. CONCLUSIONS

This project report concludes that total cost of construction by conventional method is Rs.35,72,501/- & by replacement method is Rs.29,91,062/-so total cost reduction is Rs.5,81, 439/-.Total duration required by conventional method is 32 days & by replacement method is 21 days so it reduces total days of construction is 11 Days. In our conclusion Replacement method doesn't require heavy machineries & large man power. GFRP material is easy to transport, less installation cost, less maintenance cost. Also VTS helps to reduce frauds & extra money & safety stock techniques solve the lack of inventory issues. So overall replacement method reduces the time & cost of the construction if ground base cellular tower.

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