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A Comparative Analysis Between Self-healing Bio Concrete and Conventional Concrete

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ABSTRACT

Concrete is crucial and essential material utilized in development industry from establishment of the structure to construction of scaffolds and underground entries. It tends to frame breaks when exposed to pressure or because of outside environment. It prompts decrease of solid life. Fixes of ordinary solid designs for the most part include utilization of large machines and instruments which must be exceptionally kept up. Fixes can especially be tedious and has high upkeep cost. In this way, treatment techniques that are eco-accommodating and enduring are in high demand. Bacterial Self-mending concrete is being developed now, which has improved property than that of conventional concrete. It comprises of a Bacillus animal types joined in the solid as bacterial arrangement and bacterial globules alongside its food and silica gel. Microscopic organisms recuperates the break shaped. Bacterial self-recuperating concrete has more compressive strength than that of conventional concrete. Mostly miniature breaks have been seen mending inside. The instrument and investigation of this recuperating property is momentarily portrayed in this paper. The study estimates the quantities of materials, cost and time period required completing the building with both conventional and bacterial concrete constructions. In order to analyze the value of bacterial concrete and conventional concrete construction for a building using MS Project, A G+3 storey building is taken into account. For estimation of the quantities the data of the project is been collected. The study compares the time of completion of the building and comparison of cost of building between bacterial concrete and conventional concrete construction. Both time and cost analysis of the building will be carried out in MS Project.

Keywords : Concrete, Self-healing, cracks, Bacterial solution, Precipitate, Compressive strength, Cost and duration analysis, MS Project.

1.0 Introduction

On the other hand, for example, in nature, animals and trees usually can heal small bodily damage by themselves. Generally speaking, cracks in concrete can occur in any stage of the service life of concrete structures due to concrete dryness (poorly executed cure), retraction, temperature variation, environmental aggression, accidents, corrosion of the reinforcement, load, design errors, insufficient design details, execution errors, foundations settlement and structural loads (stress, compression, bending and shear). In reinforced concrete members, Once the cracks are developed the stiffness of concrete is reduced as well as the reinforcement corrodes due to climatic factors, as a result reducing structural safety and serviceability of the structure. For concrete structures to

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avoid such damage, the application of mortar and epoxy gel can seal the crack but it requires continuous maintenance. The usage of biological agents for healing the cracks on concrete surface is desirable because it is natural and pollution free. The implementation of bioconcrete enhances the service life of concrete structures, reduces repair and maintenance costs. In the meantime, sustainability is now one of the top issues in the field of building and civil engineering from the viewpoint of global ecology. For this reason, extending the service life of structures has become a key objective. A full array of inspection and maintenance techniques for concrete structures has been developed. In some cases, however, it is difficult for engineers to access damaged sites for repair work because of their location and/or environmental conditions. Some examples are underground structural members, radioactive waste disposal facilities, and walls of tanks storing highly toxic waste. The availability of self-healing and self-repairing systems would make structures more reliable. For example, if control and repair of early-stage cracks in concrete structures were possible, we could extend the service life of the structures. For this reason, many papers have been published on self-healing and self-repairing concrete.

2.0 EXPERIMENTATION

2.1 MATERIALS& METHODOLOGY

Cement of OPC 53 grade is used in the current research work and all the properties of cement are within the limits of IS 269-2015. The specific gravity of cement is 3.1, Normal consistency of cement is 28%, Initial setting time of cement is 30 min, Final setting time of cement is 540 min. M-sand conforming Zone-II as per IS 383-2016 was used as fine aggregates. The fineness modulus of fine aggregate is 3.05 and specific gravity of fine aggregate is 2.59. The crushed granite stones of nominal size 20 mm are taken for coarse aggregate and the properties are within the guidelines of IS: 2386-1963. The specific gravity of coarse aggregate is 2.68. Potable water satisfying the specifications of IS: 456-2000 is utilized in the current experimental work.

Table 1: Chemical composition of cement.

Chemical Name	Chemical Formula	Percent Content
Lime	CaO	63.5
Silica	SiO2	22.2
Alumina	Al2O3	4.9
Iron oxide	Fe2O3	3.3
Magnesium oxide	MgO	2.6
Sulphur trioxide	SO3	2.2
Alkalis	Na2O	0.8
	K2O	0.5
Loss on ignition		1.2

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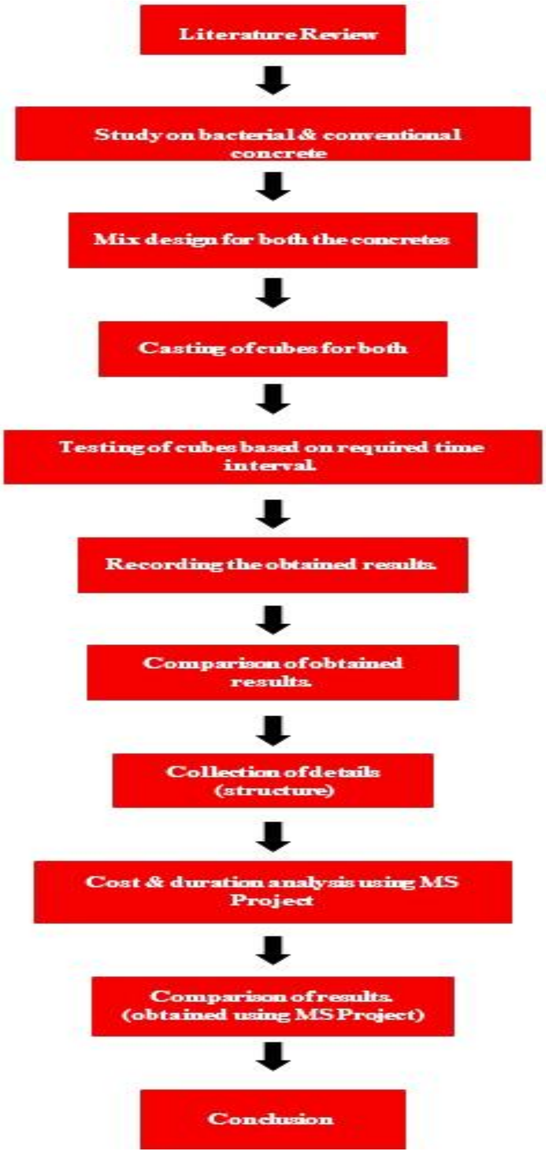

Figure 1. The strategic planning

Data Collection

Data collection is the process of collecting quantitative and qualitative information on definite variables with the aim of evaluating results. In the data collection we can also know the proceedings of the construction work and also find out the obstacles of the work. This collection is valuable to find out cost of the project for the both constructions. We also discover the project duration of the construction by using these enquiries.

3. Results

3.1 Concrete Results

3.1.1 Slump Cone Test

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch.

Table 4: Slump cone test results.

Bacteria used	M30 Grade Concrete
0 ml	25
10 ml	35
20 ml	42

3.1.2 Compaction Factor Test

Compaction factor test is the workability test for concrete conducted in laboratory. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete.

Table 5: Compaction factor test results.

Bacteria used	M30 Grade Concrete
0 ml	0.92
10 ml	0.84
20 ml	0.76

3.1.3 Compressive Strength

Compressive strength or compression strength is the capacity of a material or structure to withstand loads tending to reduce size.

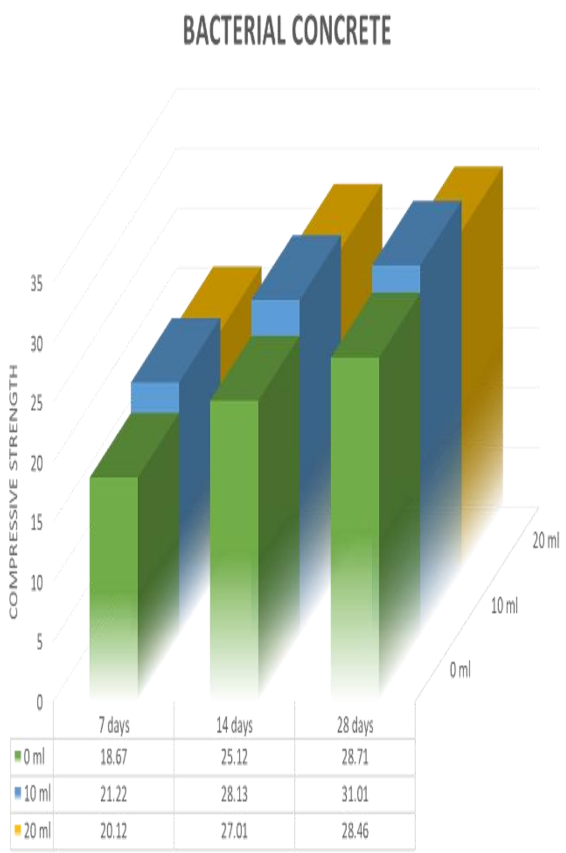

Figure 2. Graphical representation of compressive strength results of bacterial concrete.

3.1.4 Split Tensile Strength

A method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter.

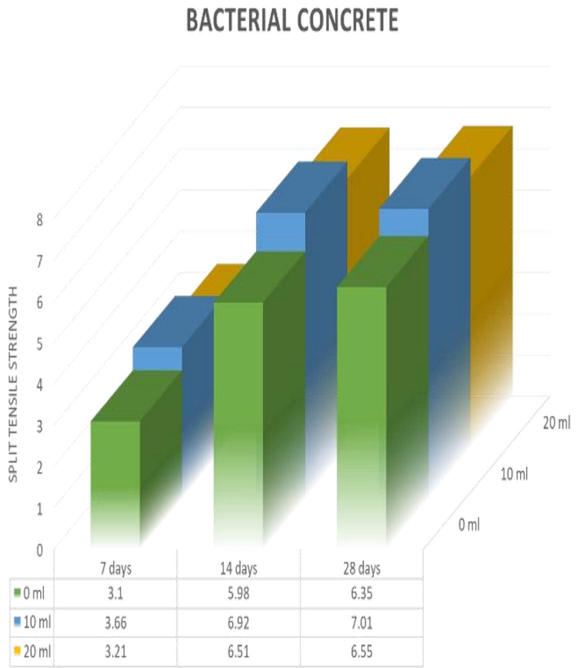

Figure 3. Graphical representation of split tensile strength results of bacterial concrete.

3.1.5 Healing of Concrete

Figure 4. The crack made in the concrete cube with Bacillus Subtilis embedded in it.

Figure 5. The crack made in the concrete cube with Bacillus Subtilis embedded in it after Self-healing.

3.2 MS Project Results

In this Study, we compare the cost and time taken for completion of conventional and bacterial concrete construction of G+3 residential building using MS Project.

The output of the project analyzed has been represented with the help of GANTT Chart for both type of the construction methods.

Results obtained are:

- ➢ Total cost required for completion – Rs. 90,17,600.00
- ➢ Total days required for completion – 520 Days
- ➢ Start date of the project – 1st November 2020

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names	WBS	Baseline Cost
1			PROJECT SUMMARY	520 days	Sun 01-11-2	Tue 28-06-2			1	₹ 9,017,600.00
2			SUBSTRUCTURE	44 days	Sun 01-11-2	Mon 21-12-:			1.1	₹ 562,700.00
3			EXCAVATION	1 day	Sun 01-11-2	Sun 01-11-2		JCB[8 Hrs]	1.1.1	₹ 8,000.00
4			DRESSING OF EXCAVATED PIT	3 days	Mon 02-11-:	Wed 04-11-:	3	MASON [2],MASON HELPER[3]	1.1.2	₹ 11,850.00
5			BED CONCRETE	2 days	Thu 05-11-20	Fri 06-11-20	4	MASON [2],MASON HELPER[3],CONCRETE[7.3 Cm]	1.1.3	₹ 48,050.00
6			FOOTING REINFORCEMENT	5 days	Tue 03-11-2	Sat 07-11-2(	5	BARBENDER[1 CHADAR],STEEL[2 MT]	1.1.4	₹ 112,300.00
7			FOOTING CONCRETE	1 day	Mon 09-11-:	Mon 09-11-:	6	CONCRETE[25 Cm]	1.1.5	₹ 137,500.00
8			FOOTING TO PLINTH COLUMN FORMWORK (USING COLUMN	3 days	Tue 10-11-20	Thu 12-11-20	7	FORMWORK[0.5 CHADAR]	1.1.6	₹ 1,150.00
9			FOOTING TO PLINTH COLUMN CONCRETE	3 days	Tue 10-11-20	Thu 12-11-20	8	CONCRETE[1.6 Cm]	1.1.7	₹ 8,800.00
10			WATER TANK (SUMP)	10 days	Fri 13-11-20	Tue 24-11-2	9	MASON [2],MASON HELPER[3]	1.1.8	₹ 39,500.00
11			BACKFILLING	2 days	Wed 25-11-:	Thu 26-11-2	10	JCB[3 Hrs]	1.1.9	₹ 3,000.00
12			COMPACTION	5 days	Fri 27-11-20	Wed 02-12-:	11	MASON [2],MASON HELPER[3]	1.1.10	₹ 19,750.00
13			PLINTH BEAM & SUMP ROOF FO	4 days	Thu 03-12-2	Mon 07-12-:	12	FORMWORK[3 CHADAR]	1.1.11	₹ 6,900.00
14			PLINTH BEAM & SUMP ROOF REINFORCEMENT	3 days	Tue 08-12-20	Thu 10-12-20	13	BARBENDER[1 CHADAR]	1.1.12	₹ 2,300.00
15			PLINTH BEAM & SUMP ROOF CO	1 day	Fri 11-12-20	Fri 11-12-20	14	STEEL[0.7 MT]	1.1.13	₹ 38,500.00
16			BACKFILLING & COMPACTION	6 days	Sat 12-12-2(	Fri 18-12-20	15	MASON [2],MASON HELPER[3]	1.1.14	₹ 23,700.00
17			6" P.C.C	2 days	Sat 19-12-20	Mon 21-12-20	16	MASON [2],MASON HELPER[3],CONCRETE[17 Cm]	1.1.15	₹ 101,400.00
18			SUPERSTRUCTURE	520 days	Sun 01-11-2	Tue 28-06-2			1.2	₹ 8,454,900.00
19			STRUCTURE	149 days	Tue 22-12-2	Fri 11-06-21			1.2.1	₹ 2,025,850.00
20			GROUND FLOOR	18 days	Tue 22-12-2	Sun 10-01-2			1.2.1.1	₹ 418,850.00
21			GF COLUMN FORMWORK	4 days	Tue 22-12-2	Fri 25-12-20	17	MASON ,MASON HELPER	1.2.1.1.1	₹ 6,600.00
22			GF COLUMN CONCRETE	4 days	Tue 22-12-20	Fri 25-12-20	21	MASON HELPER[2],MASON ,CONCRETE[1.6 Cm]	1.2.1.1.2	₹ 18,000.00
23			GF STAIRCASE FORMWORK (TILL FIRST LANDING)	2 days	Sat 26-12-20	Mon 28-12-20	22	FORMWORK[3 CHADAR]	1.2.1.1.3	₹ 6,900.00
24			GF STAIRCASE REINFORCEMENT (TILL	1 day	Tue 29-12-20	Tue 29-12-20	23	BARBENDER[2 CHADAR],STEEL[0.4 MT]	1.2.1.1.4	₹ 26,600.00
25			GF STAIRCASE CONCRETING (TILL FIRST	1 day	Wed 30-12-20	Wed 30-12-20	24	CONCRETE[0.4 Cm],MASON ,MASON HELPER	1.2.1.1.5	₹ 3,850.00
26			GF ROOF SLAB&REMAINING	5 days	Thu 31-12-20	Tue 05-01-21	25	FORMWORK[20 CHADAR]	1.2.1.1.6	₹ 46,000.00
27			GF ROOF SLAB&REMAINING	3 days	Wed 06-01-21	Fri 08-01-21	26	BARBENDER[12 CHADAR],STEEL[2 MT]	1.2.1.1.7	₹ 137,600.00
28			ELECTRICAL PIPING	1 day	Sat 09-01-21	Sat 09-01-21	27	ELECTRICIAN FOR ROOF[1 ROOF]	1.2.1.1.8	₹ 60,000.00
29			GF ROOF SLAB&REMAINING	1 day	Sun 10-01-21	Sun 10-01-21	28	CONCRETE[20 Cm],MASON [2],MASON HELPER[2]	1.2.1.1.9	₹ 113,300.00
30			FIRST FLOOR	38 days	Mon 11-01-:	Tue 23-02-2			1.2.1.2	₹ 500,450.00
31			FF COLUMN REINFORCEME	2 days	Mon 11-01-:	Tue 12-01-2	29	BARBENDER[2 CHADAR],STEEL[0.7 MT	1.2.1.2.1	₹ 43,100.00
32			FF COLUMN FORMWORK	3 days	Wed 13-01-:	Fri 15-01-21	31	MASON ,MASON HELPER	1.2.1.2.2	₹ 4,950.00
33			FF COLUMN CONCRETE	3 days	Wed 13-01-21	Fri 15-01-21	32	MASON HELPER[2],MASON ,CONCRETE[4 Cm]	1.2.1.2.3	₹ 28,900.00
34			FF INTERNAL STAIRCASE&LINTEL	4 days	Thu 28-01-21	Mon 01-02-21	81	FORMWORK[3 CHADAR]	1.2.1.2.4	₹ 6,900.00
35			FF INTERNAL STAICASE&LINTEL	3 days	Tue 02-02-21	Thu 04-02-21	34	BARBENDER[2 CHADAR],STEEL[0.8 MT]	1.2.1.2.5	₹ 48,600.00

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names	WBS	Baseline Cost
1			PROJECT SUMMARY	520 days	Sun 01-11-2	Tue 28-06-2			1	₹ 9,297,320.00
2			SUBSTRUCTURE	44 days	Sun 01-11-2	Mon 21-12-:			1.1	₹ 654,320.00
3			EXCAVATION	1 day	Sun 01-11-2	Sun 01-11-2		JCB[8 Hrs]	1.1.1	₹ 8,000.00
4			DRESSING OF EXCAVATED PIT	3 days	Mon 02-11-:	Wed 04-11-:	3	MASON [2],MASON HELPER[3]	1.1.2	₹ 11,850.00
5			BED CONCRETE	2 days	Thu 05-11-20	Fri 06-11-20	4	MASON [2],MASON HELPER[3],CONCRETE[7.3 Cm]	1.1.3	₹ 61,190.00
6			FOOTING REINFORCEMENT	5 days	Tue 03-11-2	Sat 07-11-2(	5	BARBENDER[1 CHADAR],STEEL[2 MT]	1.1.4	₹ 112,300.00
7			FOOTING CONCRETE	1 day	Mon 09-11-:	Mon 09-11-:	6	CONCRETE[25 Cm]	1.1.5	₹ 182,500.00
8			FOOTING TO PLINTH COLUMN FORMWORK (USING COLUMN	3 days	Tue 10-11-20	Thu 12-11-20	7	FORMWORK[0.5 CHADAR]	1.1.6	₹ 1,150.00
9			FOOTING TO PLINTH COLUMN CONCRETE	3 days	Tue 10-11-20	Thu 12-11-20	8	CONCRETE[1.6 Cm]	1.1.7	₹ 11,680.00
10			WATER TANK (SUMP)	10 days	Fri 13-11-20	Tue 24-11-2	9	MASON [2],MASON HELPER[3]	1.1.8	₹ 39,500.00
11			BACKFILLING	2 days	Wed 25-11-:	Thu 26-11-2	10	JCB[3 Hrs]	1.1.9	₹ 3,000.00
12			COMPACTION	5 days	Fri 27-11-20	Wed 02-12-:	11	MASON [2],MASON HELPER[3]	1.1.10	₹ 19,750.00
13			PLINTH BEAM & SUMP ROOF FO	4 days	Thu 03-12-2	Mon 07-12-:	12	FORMWORK[3 CHADAR]	1.1.11	₹ 6,900.00
14			PLINTH BEAM & SUMP ROOF REINFORCEMENT	3 days	Tue 08-12-20	Thu 10-12-20	13	BARBENDER[1 CHADAR]	1.1.12	₹ 2,300.00
15			PLINTH BEAM & SUMP ROOF CO	1 day	Fri 11-12-20	Fri 11-12-20	14	STEEL[0.7 MT]	1.1.13	₹ 38,500.00
16			BACKFILLING & COMPACTION	6 days	Sat 12-12-2(	Fri 18-12-20	15	MASON [2],MASON HELPER[3]	1.1.14	₹ 23,700.00
17			6" P.C.C	2 days	Sat 19-12-20	Mon 21-12-20	16	MASON [2],MASON HELPER[3],CONCRETE[17 Cm]	1.1.15	₹ 132,000.00
18			SUPERSTRUCTURE	520 days	Sun 01-11-2	Tue 28-06-2			1.2	₹ 8,643,000.00
19			STRUCTURE	149 days	Tue 22-12-2	Fri 11-06-21			1.2.1	₹ 2,213,950.00
20			GROUND FLOOR	18 days	Tue 22-12-2	Sun 10-01-2			1.2.1.1	₹ 458,450.00
21			GF COLUMN FORMWORK	4 days	Tue 22-12-2	Fri 25-12-20	17	MASON ,MASON HELPER	1.2.1.1.1	₹ 6,600.00
22			GF COLUMN CONCRETE	4 days	Tue 22-12-20	Fri 25-12-20	21	MASON HELPER[2],MASON ,CONCRETE[1.6 Cm]	1.2.1.1.2	₹ 20,880.00
23			GF STAIRCASE FORMWORK (TILL FIRST LANDING)	2 days	Sat 26-12-20	Mon 28-12-20	22	FORMWORK[3 CHADAR]	1.2.1.1.3	₹ 6,900.00
24			GF STAIRCASE REINFORCEMENT (TILL	1 day	Tue 29-12-20	Tue 29-12-20	23	BARBENDER[2 CHADAR],STEEL[0.4 MT]	1.2.1.1.4	₹ 26,600.00
25			GF STAIRCASE CONCRETING (TILL FIRST	1 day	Wed 30-12-20	Wed 30-12-20	24	CONCRETE[0.4 Cm],MASON ,MASON HELPER	1.2.1.1.5	₹ 4,570.00
26			GF ROOF SLAB&REMAINING	5 days	Thu 31-12-20	Tue 05-01-21	25	FORMWORK[20 CHADAR]	1.2.1.1.6	₹ 46,000.00
27			GF ROOF SLAB&REMAINING	3 days	Wed 06-01-21	Fri 08-01-21	26	BARBENDER[12 CHADAR],STEEL[2 MT]	1.2.1.1.7	₹ 137,600.00
28			ELECTRICAL PIPING	1 day	Sat 09-01-21	Sat 09-01-21	27	ELECTRICIAN FOR ROOF[1 ROOF]	1.2.1.1.8	₹ 60,000.00
29			GF ROOF SLAB&REMAINING	1 day	Sun 10-01-21	Sun 10-01-21	28	CONCRETE[20 Cm],MASON [2],MASON HELPER[2]	1.2.1.1.9	₹ 149,300.00
30			FIRST FLOOR	38 days	Mon 11-01-:	Tue 23-02-2			1.2.1.2	₹ 546,530.00
31			FF COLUMN REINFORCEME	2 days	Mon 11-01-:	Tue 12-01-2	29	BARBENDER[2 CHADAR],STEEL[0.7 MT	1.2.1.2.1	₹ 43,100.00
32			FF COLUMN FORMWORK	3 days	Wed 13-01-:	Fri 15-01-21	31	MASON ,MASON HELPER	1.2.1.2.2	₹ 4,950.00
33			FF COLUMN CONCRETE	3 days	Wed 13-01-21	Fri 15-01-21	32	MASON HELPER[2],MASON ,CONCRETE[4 Cm]	1.2.1.2.3	₹ 36,100.00
34			FF INTERNAL STAIRCASE&LINTEL	4 days	Thu 28-01-21	Mon 01-02-21	81	FORMWORK[3 CHADAR]	1.2.1.2.4	₹ 6,900.00
35			FF INTERNAL STAICASE&LINTEL	3 days	Tue 02-02-21	Thu 04-02-21	34	BARBENDER[2 CHADAR],STEEL[0.8 MT]	1.2.1.2.5	₹ 48,600.00

Figure 6. Gantt chart view for construction using bacterial concrete.

Results obtained are:

- ➢ Total cost required for completion – Rs. 92,97,320.00
- ➢ Total days required for completion – 520 Days
- ➢ Start date of the project – 1st November 2020

Project Duration

Project duration of each type of construction is analyzed using MS Project. The time of completion period is analyzed using Critical Path Method (CPM) which provides the project duration of conventional and bacterial concrete construction of the building.

It is observed that time taken for the completion of work for conventional and bacterial concrete construction is same i.e, 520 days.

Cost Analysis

This is the main aspect which is considered in the project is to find out the comparison of cost analysis of building for the conventional concrete construction and bacterial concrete construction. The study includes all the resources required for construction.

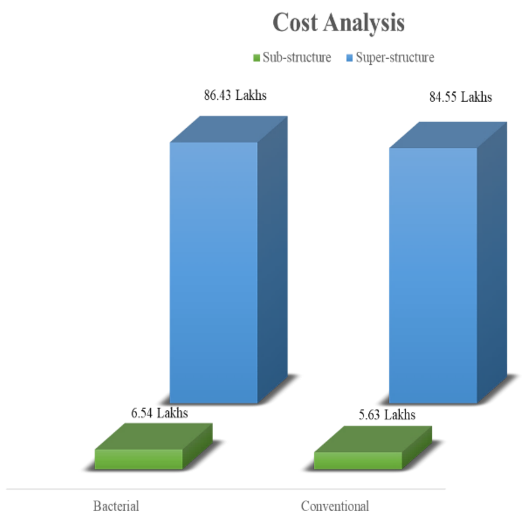

Figure 7. Cost analysis of conventional concrete and bacterial concrete.

The total project cost was calculated for both the constructions as shown in the graph. It represents the cost for bacterial concrete construction is higher than the conventional construction by some fraction. The cost required for completion of the project using bacterial concrete is around 3.2% higher than the conventional construction.

Network Diagram

A Network Diagram is a graphical way to view tasks, dependencies, and the critical path of your project. Boxes (or nodes) represent tasks, and dependencies show up as lines that connect those boxes.

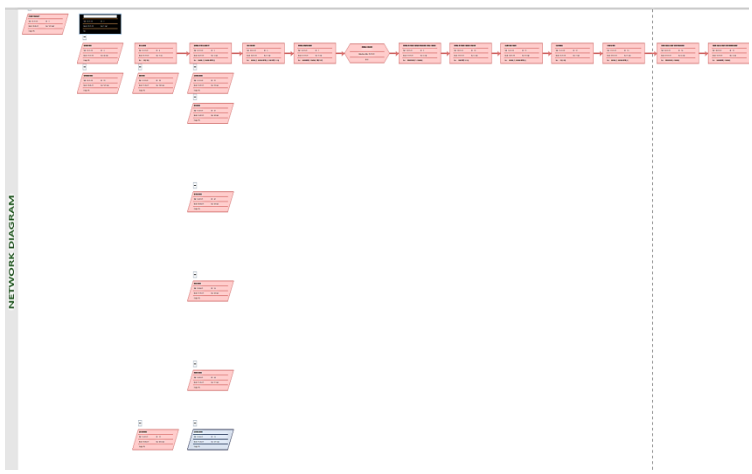

Figure 8. Network Diagram

Conclusion

we compare the cost and time taken for completion of conventional and bacterial concrete construction of G+3 residential building using MS Project.

The output of the project analyzed has been represented with the help of GANTT Chart for both type of the construction methods.

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