"FEASIBILITY STUDY OF GREEN BUILDING IN METRO'S OPERATION"

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Abstract: *. To increase the share of public transport, many Indian cities are developing rail-based Mass Rapid Transit System (MRTS). Currently metro rail system (a type of rail-based MRTS) are operating in 8 cities, 7 more cities are developing metros which are under different stages of construction and 23 more cities are planning to have metro rail system. Similarly several cities are planning for mono rail and light rail system which re under various stages of development. Against this background, CII's Indian Green Building Council (IGBC) has launched 'IGBC Green Mass Rapid Transit System (MRTS) Rating Version 1.0 Abridge Reference Guide. This rating system is tool to enable new rail-based MRTS to apply green concept during design and construction, so as to further reduce environmental impact that are measurable. The overarching object of IGBC Green MRTS Rating is to ensure environmental sustainability, while enhancing commuter experience.*

Keywords: Green Building Technology, Relative importance index

1.INTRODUCTION

1.1 BACKGROUND

India is experiencing phenomenal growth in urban population in the last few decades. As per 2011 census, 31% of India's total population resides in urban areas. It is estimated that by the year 2030, the urban populations would be rise to 42% of the total population of the country. As a result India is witnessing tremendous growth in transportation sector and the share the share of private modes of transport such as two-wheeler and four-wheeler is increasing exponentially. To increase the share of public transport, many Indian cities are developing rail-based Mass Rapid Transit System (MRTS). Currently metro rail system (a type of rail-based MRTS) are operating in 8 cities, 7 more cities are developing metros which are under different stages of construction and 23 more cities are planning to have metro rail system. Similarly several cities are planning for mono rail and light rail system which re under various stages of development. At present, Metro Rail authorities in India have many international organizational policies in place to sustainability manage environmental resource few such policies include Energy Management Policies, Environment Policies, Waste Management Policies and Water Policies. However, there is a need to have a definitive & voluntary standard for green design, construction and operation of metro rail projects.

Against this background, CII's Indian Green Building Council (IGBC) has launched 'IGBC Green Mass Rapid Transit System (MRTS) Rating Version 1.0 Abridge Reference Guide. This rating system is tool to enable new rail-based MRTS to apply green concept during design and construction, so as to further reduce environmental impact that are measurable. The overarching object of IGBC Green MRTS Rating is to ensure environmental sustainability, while enhancing commuter experience.

1.2 GREEN BUILDING TECHNOLOGY

This chapter presents an overview of green building and it divided into three sections. The first section discusses what makes buildings green and gives several definition of green building. The second section discusses the environmental impacts of traditional building and explains common green building practices with respect to siting, energy efficiency, water efficiency, building material, occupant health, and well-being, and construction and demolition waste. The third section discusses the role of lawyers in the green building field.

This chapter provides a brief overview of issues that are discussed in more details in subsequent chapters. Citations to these later chapters are included where applicable.

1.3 Research Objective

Against this background the purpose of this research is to answer the research questions. What is the level of feasibility of green building technology in construction of MRTS. More specifically, this research has the following objectives.

- To analyze the acceptance criteria of Green Building Concept in Metro rail.
- Which economic, environmental and social indicators will be fruitful in long run due to Application of Green

Building Technology.

1.4 PROBLEM STATEMENT

Construction and operation of various modes of mass rapid transport system require huge quantity of material, which is detrimental for our natural resources. Also the use of energy and water causes emission of greenhouse gases. Green building technology can play significant role in cutting of GHG emission, decrease in use of natural resources and increasing user friendly environment in MRTS.

1.5 METHODOLOGY

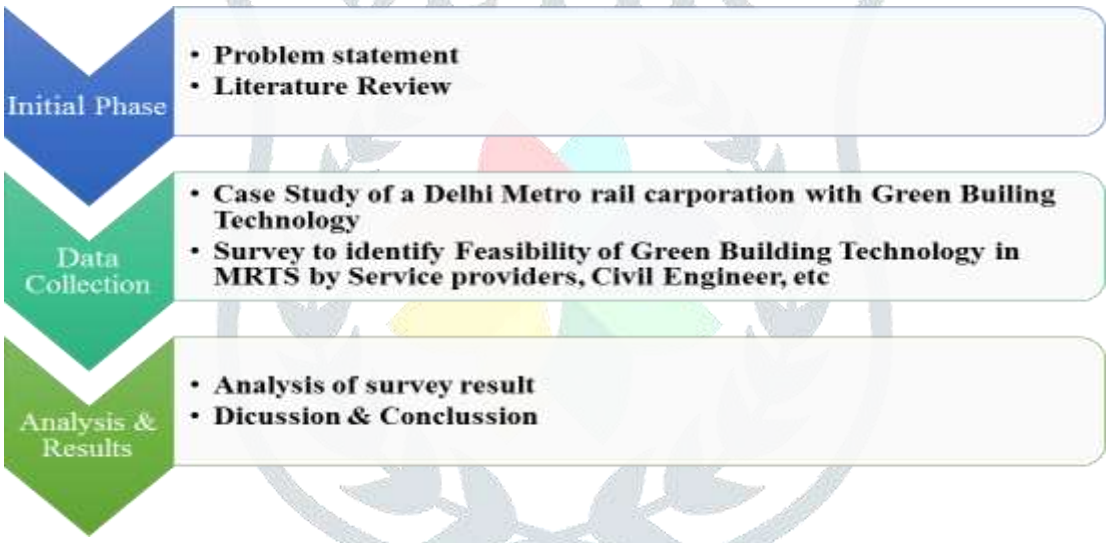
Comprehensive study of Delhi Metro Rail was done by data collection and available literature, also a questionnaire survey was done to analyze the feasibility of adopting Green Building concept in construction of MRTS. Added knowledge on Green Building Technology was acquired using internet and various magazines and journals.

1.6 LIMITATION OF STUDY

Scope of this thesis is limited:

- Numbers of professional working on Green Building projects are very less.
- Limited availability of literature of application of Green Building

2 PROJECT METHODOLOGY



3 CASE STUDY

3.1 INTRODUCTION

The Delhi Metro Rail Corporation (DMRC) is headquartered in New Delhi, India. It was registered in the year 1995 under the Companies Act 1956 with equal equity participation from the Government of the National Capital Territory of Delhi (GNCTD) and the Central Government. The organization is implementing the construction and operation of a world–class Mass Rapid Transport System (MRTS), since its inception.

DMRC has two major divisions – the projects division which is responsible for construction activities and the Operation and Maintenance (O&M) division which is responsible for all operation and maintenance activities.

DMRC has formulated Policies on Environment Management, Energy Management, Water Management, Waste Management, Quality, QEHS and Solar Energy, which guide the multifarious activities that take place under its 'Project' and 'Operation & Maintenance' departments.

This 'Management by Objectives' approach has paid rich dividends. It has helped DMRC become carbon neutral. It has led to significant contributions in arresting climate change, successfully demonstrated through its projects under the Clean Development Mechanism (CDM) and the Gold Standard (GS), which are internationally acclaimed and are in public domain. DMRC is now fully transitioned to a 'Sustainable Built Environment' and its approximately 14 million square feet of structures and facilities coming up as part of Phase-III construction (which is 63% of the MRTS under certification in the whole country) are being built to the highest "Green Standards" as mandated by IGBC. What is more, DMRC is planning to add nearly equal square footage of its existing stations also under IGBC mandated green certification.

3.2PROJECT BRIEF

OVERVIEW	
Owner	Delhi Metro Rail Corporation Ltd.(DMRCL)
Locate	NCR, INDIA
Transit Type	Rapid Transit/ Metro
Number of Lines	8 Color-Coded lines
Number of Stations	185, including 6 airport express stations
Daily Ridership	Average 2.76 million
Annual Ridership	1 billion (FY 2016/17)
OPERATION	
Began Operation	24 December 2002
Operator	Delhi Metro Rail Corporation
Number of Vehicle	314 Trains
Train Length	4/6/8 Coaches
TECHNICAL	
System Length	252

3.3 USE OF RENEWABLE ENERGY

In energy-deficient India, DMRC's energy intensive operations for instance, could have been an additional burden on the overall energy availability from coal. DMRC explored alternative energy sources and divested into using solar energy in line with its Solar Energy Policy. DMRC has already installed 6.2 MWp capacities of roof top solar power plants. By 2017 this will go up to 20 MWp and by 2021 it is planned to install 50 MWp. This would then ensure that 1/3 rd of current total energy consumption of DMRC is met from renewable energy.

Figure 3.1 Renewable Energy

a. ENERGY CONSERVATION MEASURES

DMRC recognized this important aspect early and therefore a number of measures have been taken during the planning and design stage to minimize energy consumption and mitigate negative impact on the environment.

i. Some of the measures taken during the planning, design and O&M stage include:

ii. Construction of most of the stations on a hump.

iii. Use of regenerative braking resulting in energy saving of about 30-40% of Traction Energy.

iv. Design of coaches:-

1. Reduction in Tare weight of coach by use of stainless steel
2. Increased passenger capacity per coach
3. Variable Voltage Variable Frequency drives

- Selection of 25 kV ac traction, which resulted in reduction in equipment sizing, lower losses in the equipment and in turn more efficient system.
- Selection of closed system, where the conditioned air gets re-circulated
- Adopting of 1% design criterion
- Choice of acceptable conditions inside coaches and stations areas using Relative Warmth Index.
- Selection of Energy Efficient VAC Equipment.

b. WATER CONSERVATION

Considering water as a very important constituent for human and eco-system health and that its availability is becoming rarer, DMRC is very much concerned with water conservation and management in construction as well as operation & maintenance.

c. WASTE MANAGEMENT

The DMRC has adopted various methods to assess and minimize waste generation, to re-utilize/ recycle the waste and to operate in full compliance with applicable environmental laws.

DMRC has adopted following measures to identify, recycle and reuse waste:

- Recycling of paper waste. So far, DMRC has recycled 32 ton of waste paper into useful office stationary. The table below shows the savings on account of recycling of this amount of paper.

S.No.	Content	Quantity	Unit
1.	Power savings	57.6	MWh
2.	Coal consumption avoided	64	Tons
3.	CO_2 emission reduction	91.07	tCO_2 eq.
4.	Furnace oil consumption avoided	1280	Litres
5.	Water consumption avoided	8000	KLD
6.	Waste water generation avoided	224	KLD
7.	Bamboo (moisture free) saved	70.40	Tons
8.	Area of Bamboo plantation/ton saved	4.40	Hectare
9.	Chemicals such as caustic soda/salt cake, chlorine, talcum powder, alum, resin, dyes avoided	18.56	Tons

- As a respectable construction agency, DMRC has been ensuring recycling of Construction and Demolition waste generated from its construction activities. So far, DMRC has recycled 2.00 lakh tone of C&D waste into useful products such as tiles, blocks, paving blocks, kerb stones etc. DMRC is now planning to develop its own C&D waste recycling facility.

4. QUESTIONNAIRE SURVEY

4.1 INTRODUCTION:

This chapter deals with the data collected from the questionnaire survey and its analysis. The questionnaire analysis is divided into five parts that reflects the introduction, profile of the respondent, the advantage/disadvantages of the use of green building technology and the strategies to overcome the barrier for wider use of green concept. The data from each question is graphically represented by means of a pie-chart or graph so that the reader may interpret the results with ease. The statistical analysis of the data can then follow.

4.2 SAMPLING

The survey research methodology has been adopted for this research. The target population consists of Clients, Contractors and Consultant from construction industry. Due to financial and time constraint, a target population of 75 respondents was set, consisting of clients, contractor, supplier, and consultants along with other professional. While designing the questionnaire, consideration have been taken for the aim and the objective of

the study with an intention to provide sufficient background and to obtain professional opinions from the industry to cover the issues that are within the limits of this research work. The findings of the literature review were used as a basis for the questionnaire's content and its format.

4.3 QUESTIONNAIRE FORMAT

The structured questionnaire format is used and a multi-point rating questionnaire is used to rate respondent's opinions. In order to present the questionnaire in systematic way, it was decided to divide the questionnaire into three major sections to cover the main issues under investigation. And a wide array of questions were related to the field of study with answer to be given in

4.4 DEMOGRAPHIC VARIABLES

The information was gathered in the following fashion: Part 1: Introduction and basic information of the respondent. Part: 2 Respondent's profile -- Respondents experience in Building construction industry – Respondents company type – Respondents experience in Green Building Project. Part 3: Source of knowledge and Perceived benefits and limitations of precast. Part 4: Disadvantages/barriers of Green Building technology. And finally Part 5: Opinion about encouragement and involvement by Government for use of green concept in future construction project etc.

4.5 SURVEY RESULTS

Following are the results of the survey conducted among 45 professionals.

4.5.1 Part I. Profile of the Respondent

This section of questionnaire aims to obtain information relating to the participating organization and their field of work.

4.5.1.1 Respondent's firms role in construction industry

The participant needs to select the type of his organization in construction industry from the given categories. Out of 45 respondents 47% are from the contractor companies, 18% are clients, 18% are consultant, 15% are others and 2% are from suppliers' side.

5 .ANALYSIS AND DISCUSSION OF RESULTS

5.1 Relative importance index analysis:

RII is a useful technique to calculate the relative importance of predictors when the independent variables are correlated to each other.

The contribution of each of the factors is examined and the ranking of attribute in terms of their criticality as perceived by respondents are done by relative important index. Calculations are done using following formula.

RII= (SUM OF W)/ (A*N)

W= Weight given to each factor by the respondent N= Total number of respondent

A= Highest Weight

RII calculations for determining major advantages of usage of Green Building technology.

The respondents are tabulated below and weightage with RII calculated are shown below the respective tables.

Responses on advantage of using Green Bulding Technology										
Rating	Reduced cost for site preparation, parking lots and roads.	Lower energy cost and optimal orientation	Less landscape maintenance cost	Reduced annual water costs and wastewater costs.	Lower cost for waste disposal and new landfills	Lower annual fuel and electricity costs due to reduced peak power demand	Reduced demand for new energy infrastructure, lowering energy costs to consum	Reduced operating cost of structure	Improved occupants productivity	Minimize strain on local infrastructure
1	1	1	0	2	0	0	0	0	1	0
2	2	2	10	2	5	5	6	6	6	4
3	18	14	13	18	17	17	20	18	17	14
4	20	20	12	12	17	17	12	15	14	19
5	4	10	10	11	6	6	9	6	7	8
Total Repondents	45	45	45	45	45	45	45	45	45	45

Table 5.1: RII calculations for determining advantages of Green Building-I

Weightage and RII calculation										
Rating	Reduced cost for site preparation, parking lots and roads.	Lower energy cost and optimal orientation	Less landscape maintenance cost	Reduced annual water costs and wastewater costs.	Lower cost for waste disposal and new landfills.	Lower annual fuel and electricity costs due to reduced peak power demand	Reduced demand for new energy infrastructure, lowering energy costs to consum	Reduced operating cost of structure	Improved occupants productivity	Minimize strain on local infrastructure
	1	1	0	2	0	0	0	0	1	0
	4	4	20	4	10	10	12	12	12	8
	54	42	39	54	51	51	60	54	51	42
	80	80	48	48	68	68	48	60	56	76
	20	50	50	55	30	30	45	30	35	40
Total	159	177	157	163	159	159	165	156	155	166
RII	0.707	0.742	0.698	0.724	0.738	0.707	0.689	0.693	0.689	0.738
Rank	23	9	27	16	12	23	29	28	29	12

Table 5.2: RII calculation for weightage of advantages with ranking-I

Responses on advantages using Green Building Technology										
Rating	Improved occupant health and comfort	Decreased replacement cost for more durable material	Land preservation	Protection of ecological resources	Soil and water conservation	Lower potable water use and pollution discharges to waterways.	Less strain on aquatic ecosystems in water scarce areas.	Preservation of water resource for wildlife and agriculture	Lower electricity and fossil fuel use	Less air pollution and carbon dioxide emissions.
1	2	1	1	0	0	1	1	1	2	0
2	3	5	5	6	5	3	4	2	5	2
3	17	16	11	9	11	11	13	14	13	16
4	15	19	21	18	19	19	16	19	16	15
5	8	4	7	12	10	11	11	9	9	12
Total Response	45	45	45	45	45	45	45	45	45	45

Table 5.3: RII calculation for determining advantages in Green Building-II

	Weightage and RII calculations									
	Improved occupant health and comfort	Decreased replacement cost for more durable material	Land preservation	Protection of ecological resources	Soil and water conservation	Lower potable water use and pollution discharges to waterways.	Less strain on aquatic ecosystems in water scarce areas.	Preservation of water resource for wildlife and agriculture	Lower electricity and fossil fuel use	Less air pollution and carbon dioxide emissions.
	2	1	1	0	0	1	1	1	2	0
	6	10	10	12	10	6	8	4	10	4
	51	48	33	27	33	33	39	42	39	48
	60	76	84	72	76	76	64	76	64	60
	40	20	35	60	50	55	55	45	45	60
Total	159	155	163	171	169	171	167	168	160	172
RII	0.707	0.689	0.724	0.76	0.751	0.76	0.742	0.747	0.711	0.764
Rank	23	29	16	4	6	4	9	7	20	3

Table 5.4: RII calculation for weightage of advantage with ranking-II

RII Calculations for determining major disadvantages of usage of Green building technology

The respondents are tabulated below and weightage with RII calculated are shown below the respective tables.

Responses on disadvantages of green building technology										
Rating	High initial capital cost	Lack of financing institution	Long payback period.	Low internal rate of return	High cost of sustainable material	High cost of equipment and machinery(water treatment and HVAC	Lack of government supporting policy	Lack of awareness among public	Reluctance to adopt new technology.	Tedious procedure for obtaining certification.
1	2	2	2	2	2	2	1	0	0	0
2	4	7	8	7	7	6	7	8	7	4
3	14	19	12	14	14	23	13	11	13	17
4	15	14	14	16	14	8	16	16	18	19
5	10	3	9	6	8	6	8	10	7	5
Total Responses	45	45	45	45	45	45	45	45	45	45

Table 5.7: RII calculation for determining disadvantages in Green Building-I

Weightage of RII calculation										
	High initial capital cost	Lack of financing institution	Long payback period.	Low internal rate of return	High cost of sustainable material	High cost of equipment and machinery(water treatment and HVAC	Lack of government supporting policy	Lack of awareness among public	Reluctance to adopt new technology.	Tedious procedure for obtaining certification.
	2	2	2	2	2	2	1	0	0	0
	8	14	16	14	14	12	14	16	14	8
	42	57	36	42	42	69	39	33	39	51
	60	56	56	64	56	32	64	64	72	76
	50	15	45	30	40	30	40	50	35	25
Total	162	144	155	152	154	145	158	163	160	160
RII	0.72	0.64	0.6889	0.6533	0.6844	0.6444	0.7022	0.7156	0.7111	0.7067
Rank	1	17	8	14	9	16	5	2	3	4

Table 5.8: RII calculation of weightage of disadvantages with ranking-I

Responses on disadvantages of green building technology									
Rating	Lack of sustainable materials	Lack of Technical expertise	Shortage in availability of skilled manpower	Lack of experience and required skill set	Geographical location of site	Lack of quality assessment tools	Fewer codes/standard available	Poor integration with traditional method	Currently not taught in academic courses
1	0	0	1	3	0	1	1	3	1
2	6	9	8	7	7	8	13	12	9
3	18	18	14	16	20	16	13	12	11
4	17	14	18	14	12	16	14	10	15
5	4	4	4	5	6	4	4	8	9
Total Responses	45	45	45	45	45	45	45	45	45

Table 5.9: RII calculation for determining disadvantages in Green Building-II

	Weightage of RII calculation								
	Lack of sustainable materials	Lack of Technical expertise	Shortage in availability of skilled manpower	Lack of experience and required skill set	Geographical location of site	Lack of quality assessment tools	Fewer codes/standard available	Poor integration with traditional method	Currently not taught in academic courses
	0	0	1	3	0	1	1	3	1
	12	18	16	14	14	16	26	24	18
	54	54	42	48	60	48	39	36	33
	68	56	72	56	48	64	56	40	60
	20	20	20	25	30	20	20	40	45
Total	154	148	151	146	152	149	142	143	157
RII	0.6933	0.6578	0.6711	0.6489	0.6667	0.6622	0.6311	0.6356	0.6978
Rank	7	13	10	15	11	12	19	18	6

Table 5.10: RII calculation of weightage of disadvantages with ranking-II

RII calculations for determining major strategies to overcome barrier in Green Building

Technology

Responses on strategies to increase usage of green building technology								
Rating	More research in GBT should be done to overcome cost barrier	Adoption of proper planning tools to overcome project delays	Developing cheaper construction methodology	Govt. should bring policy to simplify and increase availability of financing/ insurance	Starting academic and training program in educational institutions.	Educating public about the long term benefits of GBT	Reduce taxation on sustainable material, equipment, tools and machinery	Giving incentives in form of tax benefits to the owners. (e.g. property tax, other
1	3	1	1	1	0	0	2	0
2	4	3	4	4	7	7	3	4
3	9	13	17	14	12	15	16	14
4	15	17	10	11	18	16	13	18
5	14	12	13	15	8	7	11	9
Total Responses	45	46	45	45	45	45	45	45

Table 5.11: RII calculation for weightage of strategies to be implemented to overcome the barriers

Weightage on RII calculation								
	More research in GBT should be done to overcome cost barrier	Adoption of proper planning tools to overcome project delays	Developing cheaper construction methodology	Govt. should bring policy to simplify and increase availability of financing/ insurance	Starting academic and training program in educational institutions.	Educating public about the long term benefits of GBT	Reduce taxation on sustainable material, equipment, tools and machinery	Giving incentives in form of tax benefits to the owners. (e.g. property tax, other
	3	1	1	1	0	0	2	0
	8	6	8	8	14	14	6	8
	27	39	51	42	36	45	48	42
	60	68	40	44	72	64	52	72
	70	60	65	75	40	33	55	45
Total	168	174	165	170	162	158	163	167
RII	0.747	0.751	0.733	0.738	0.72	0.702	0.724	0.742
Rank	2	1	5	4	7	8	6	3

Table 5.12: RII calculations with rankings for weightage of strategies to be implemented to overcome barriers

RII Ranking & Discussions

In the below tables the ranking of various advantages, disadvantages and strategies are shown on the basis of RII analysis. This ranking will help us to understand that though there are a lot of advantages associated with green building technology, the advantages are comparatively more (RII value is more for advantages). In the below table advantages, disadvantages and strategies are ranked separately.

Rankings based on RII calculations					
S.NO.	Advantages	Rank	S.No.	Advantages	Rank
1	Reduced cost for site preparation, parking lots and roads.	23	16	Lower potable water use and pollution discharges to	4
2	Lower energy cost and optimal orientation	9	17	Less strain on aquatic ecosystems in water scarce	9
3	Less landscape maintenance cost	27	18	Preservation of water resource for wildlife and	7
4	Reduced annual water costs and wastewater costs.	16	19	Lower electricity and fossil fuel use	20
5	Lower cost for waste disposal and new landfills .	12	20	Less air pollution and carbon dioxide emissions.	3
6	Lower annual fuel and electricity costs due to reduced peak power demand	23	21	Better air quality inside the facility, including reduced volatile organic emissions ,	2
7	Reduced demand for new energy infrastructure, lowering energy	29	22	Increase in local recycling market	1
8	Reduced operating cost of structure	18	23	Lower energy use for material transportation	26
9	Improved occupants productivity	29	24	Improved aesthetics.	20
10	Minimize strain on local infrastructure	12	25	Increased transportation options for the employs.	19
11	Improved occupant health and comfort	23	26	Preservation of water resources for future generations and for	14
12	Decreased replacement cost for more durable material	29	27	Fewer waste water treatment plants	18
13	Land preservation	16	28	Fewer power plant and new transmission line.	7
14	Protection of ecological resources	4	29	Expended market for environmentally preferable products	15
15	Soil and water conservation	6	30	Decreased traffic due to the use of local/regional material	9

Table 5.12: RII ranking for various advantages of Green building

In advantages, Increase in local recycling market is ranked first followed by better air quality inside quality including reduced volatile organic emissions, less air pollution and carbon dioxide emissions, protection of ecological resources and so on.

Rankings based on RII calculations					
S.No.	Disadvantages	Rank	S.No.	Disadvantages	Rank
1	High initial capital cost	1	11	Lack of sustainable materials	7
2	Lack of financing institution	17	12	Lack of Technical expertise	13
3	Long payback period.	8	13	Shortage in availability of skilled manpower	10
4	Low internal rate of return	14	14	Lack of experience and required skill set	15
5	High cost of sustainable material	9	15	Geographical location of site	11
6	High cost of equipment and machinery water treatment and HVAC	16	16	Lack of quality assessment tools	12
7	Lack of government supporting policy	5	17	Fewer codes/standard available	19
8	Lack of awareness among public	2	18	Poor integration with traditional method	18
9	Reluctance to adopt new technology.	3	19	Currently not taught in academic courses	6
10	Tedious procedure for obtaining	4			

Table 5.13: RII rankings for various disadvantages of Green Building

In disadvantages, high initial capital cost is rank first followed by lack of awareness among people, reluctance to adopt new technology, tedious procedure for obtaining and so on. Anyhow if we compare the RII value of advantages are given more ratings.

S.NO.	RII rankings for the ginen strategies	Ranking
1	More research in GBT should be done to overcome cost barrier	2
2	Adoption of proper planning tools to overcome project delays	1
3	Developing cheaper construction methodology	5
4	Govt. should bring policy to simplify and increase availability of financing/ insurance.	4
5	Starting academic and training program in educational institutions.	7
6	Educating public about the long term benefits of GBT	8
7	Reduce taxation on sustainable material, equipment, tools and machinery	6
8	Giving incentives in form of tax benefits to the owners. (e.g. property tax, other statutory taxes.)	3

When it comes to strategies, in the bellow table various suggestions are given and ranking is presented for all of them.

Table 5.14: RII ranking of strategies to increase the use of Green Building in India

CONCLUSION OF SURVEY

After conducting the RII analysis, the results portrayed similar signs to what was documented in the literature review. The analysis concluded that the following factors affecting the use of Green Building Technology positively in India are.

- Increase in local recycling market.
- Better air quality, reduce volatile organic emissions.
- Less air pollution and Carbon dioxide emissions.
- Protection of ecological resources.
- Lower portable water used and pollution discharge.

The productivity statistical analysis portrayed the following information that negatively affected the green building technology.

- High initial capital cost.
- Lack of awareness among people.
- Reluctance to adopt new technology.
- Lack of government supporting policy.
- Lack of sustainable materials.

The analysis regarding strategies mainly shows government environment in financing and providing incentives plays a vital role for future expansion in use of green building technology in India.

6. SUMMARY & CONCLUSIONS

6.1 SUMMARY

The two methods of research are adopted for the study that is case study and questionnaire design based on survey research. The questionnaire is designed for service providers which include builders, contractors, and engineers having civil engineering background. Case study is done to assess the duration taken by precast method project. The literature review is kept in mind while designing the questionnaire for both.

6.2 CONCLUSIONS

In India Green Building Technology is still on the child stage. Only the high end builders are adopting this technology for their corporate and residential clients. Apart from this government is promoting this technology in mass rapid transportation system. It is observed from survey that there is positive built up is going on behind the feasibility of Green Building Technology if factors like high initial cost and lack of technical expertise is reduced. The dependability comes from financial point of view if the measures are adopted to solve this issue than its acceptance will also be increased.

The research ends with following conclusion drawn from questionnaire survey and case study:

6.2.1 Everyone understands and agrees the advantages of Green Building Technology in terms of sustainability, water efficiency, energy efficiency and indoor air quality will be helpful in indirect saving in money in long term. It will also improve the user experience and productivity.

6.2.2 All above advantages will have a direct impact on environmental factors. Its adoption in MRTS will indirectly helpful in mitigation of greenhouse gases particularly carbon dioxide. Also the problems related to waste disposal can be checked.

6.2.3 In spite of having above mentioned advantages of Green Building technology, it is used on small scale. But government funded mass rapid transport system are adopting it on priority basis.

6.2.4 Few disadvantages like lack of technical expertise and its integration with traditional method are there, but it can be solved by adopting various strategies.

6.2.5 Change in taxation policy by government will enhance the market for Green Building materials and equipment which will ultimately increase the adoption of Green Building technology.

Final conclusion is in order to give our current and future generation an eco- friendly and sustainable mass rapid transport system, we should apply Green Building Technology in construction of MRTS. The benefits associated with Green Building Technology on economic, social and environmental front makes it feasible in mass rapid transport system. It is always better to look into wealth maximization rather than profit maximization. This thesis is an effort to demonstrate technology which can make MRTS construction much more environment friendly, energy efficient in its operation and help in substantial contribution to GDP growth.

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