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SUSTAINABLE DEVELOPMENT: REHABILITATION OF OLD STRUCTURE AND GENERATION OF SOLAR ENERGY

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Abstract: This study discusses the ways of using solar energy to increase the efficiency of old elevated water tank, reduce the negative impact on environment of traditional power generation methods and encourage sustainable development. As we know traditional generation of electricity uses conventional energy sources. Conventional energy sources are not only in limited amount in nature but also cause negative impacts on the environment. Electricity has become one of the most basic needs of human life and demand is increasing day by day. Since the conventional energy sources are non-renewable and to meet the increasing demand, there's an urgent need to shift to the non-conventional or renewable energy sources. Due to rapid growth in construction industry over the years, it is affecting the environment negatively. Thus, sustainable development practices in the construction industry in necessary.

This study aims at encouraging ways to generate electricity using solar energy. There are many ways of using solar energy for electricity generation but this particular study will focus on generation of electricity by rehabilitating an old elevated water tank and installing solar panels on its top surface thus, increasing its efficiency and making it cost efficient in the long run. The main aim is to encourage sustainable development is construction industry.

Generation of electricity through solar energy helps in sustainable development. Though the initial solar panel installation has high cost but it turns out to be cost efficient in long run. This study proposes rehabilitation of the old elevated water tank after checking its strength by performing Non-destructive test and installation of solar panels on the top surface of old elevated water tank to generate electricity for pumping of water.

IndexTerms - Conventional energy, Rehabilitation, Cost efficient, Sustainable development, Non-destructive test, construction industry

Introduction

1.1 Definition of rehabilitation of structure

Rehabilitation of structure means repair, reconstruction or renovation of any building or structure that had or has lost its strength due to various reasons. The rehabilitation of structure can be understood as the set of operations which aim to increase the level of quality of building systems so as to achieve compliance with functional requirement standards which are stricter than those planned.

1.2 Need of rehabilitation of structure

Many old structures around the world are in urgent need reinforcement, repair or reconstruction due to structural damage caused over the years due to various reasons. As a kind of counterpoint to the changes caused by rapid technological evolution, it is really important to keep existing built environment and passing it on to future generations. Rehabilitated buildings have their usage value restored and their obsolescence reversed. To be effective in restoring the use value, the building rehabilitation should be feasible in those 3 aspects.

1.3 Non-conventional energy definition

Non-conventional sources of energy are the energy sources which are continuously replenished by natural process. These cannot be exhausted easily, can be generated constantly so can be used again and again. Eg – Solar energy, Tidal energy, Biomass energy, Geothermal energy, etc.

1.4 Need of non-conventional energy

Non-conventional sources of energy are considered to be important as they are renewable, pollution free, availability of them is in abundance and they are environment friendly.

Since the conventional energy sources are causing negative effects on environment, there is an urgent need to depend less on conventional energy and more on the non-conventional energy.

Because of the increase of population and usage of conventional energy sources, there is a potential danger of limited reserves of conventional energy sources, such as coal, petrol, diesel, crude oil, natural gas getting exhausted in future.

1.5 Solar Energy

Solar energy is radiant light and heat from the sun that is harnessed using range of technologies such as solar power to generate electricity, solar thermal energy (including solar water heating), and solar architecture. It is an essential source of renewable energy, and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power.

1.6 Benefits of solar energy

- Solar power is good for environment.
- Solar electricity makes your home go off the grid.
- Solar power can use under utilized land.
- Solar power causes less electricity loss.
- Solar power improves great security.
- Solar power creates jobs and helps in growth of national economy.

1.7 Non-destructive test

Non-destructive test is a method of testing existing concrete structures to assess the strength and durability of concrete structure. In the non-destructive method of testing without loading specimen to failure (i.e. without destructing concrete) we can measure the strength of concrete. Now a day this method has become a part of quality control process. This method of testing also helps us to investigate crack depth, micro cracks and deterioration of concrete.

Non-destructive method of concrete is a very simple method of testing but it requires skilled and experienced persons having some special knowledge to interpret and analyse test results.

Non-destructive tests of concrete are method to obtain the compressive strength and other properties of concrete from existing structure. Thus, the standard method of evaluating the quality of concrete in buildings or structures is to test specimens cast simultaneously for compressive, flexural and tensile strengths. The main disadvantages are that the results are not obtained immediately; that concrete in specimens may differ from that in actual structure as a result of different curing and compaction conditions; and that strength properties of concrete specimen depend on its size and shape.

Methods of non-destructive testing of concrete –

1. Surface hardness test
2. Penetration test on concrete
3. Pullout technique
4. Ultra-sonic pulse velocity test

5. Rebound hammer test

1.8 Scope of project

Maximum power is generated using conventional energy sources and since these sources are limited and are severely causing climate change and global warming, we can make use of solar energy which is a non-conventional energy source to generate electricity for the water tanks to operate smoothly even during power cuts and not cause inconvenience to the people.

The future scope of this project is –

- Increasing efficiency of land.
- Minimizing use and dependency of non-renewable resources.
- Minimizing cost of electricity required, making it economically feasible in long run.
- Storing maximum energy by rotating the direction of panels with respect to position of sun which can later be used during emergency times and rainy days, hence, reducing the cost.

1.9 Objectives

- Encourage sustainable development by rehabilitating an old structure recognising its need and increase the efficiency of the property as well as the land it is built on by installing solar panels on it.
- Perform structural tests on the existing water tank to determine current strength of the structure through Non-destructive testing. (Rebound hammer test and Ultra-sonic pulse velocity test).
- Determine the amount of power required to pump water to elevated tank.
- Minimize the land requirement for solar plant.
- Determine the number of solar panels to be installed to produce the required amount of power.
- Minimize the cost of power requirement in long run.
- Minimize the inconvenience caused by power cuts.

Research Methodology

2.1Background study

Sustainable development suggests that the construction industry should adopt practices that adhere to sustainability principles such as environment friendly design, durability, energy efficiency, cost efficiency, waste reduction, improved indoor air quality, water conservation and use of sustainable building material in construction. Rehabilitation of structure means repair, reconstruction or renovation of any building or structure that have or has lost its strength due to various reasons. Solar energy is radiant light and heat from the sun that is harnessed using a range of technologies such as solar power to generate electricity, solar thermal energy and solar architecture. It is an essential source of renewable energy, and its technologies are broadly characterised as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power.

2.2 Review of literature

The studies carried out earlier show how installation of solar panels on historical buildings, sacred buildings, old structures etc have been proved to be cost efficient and encouraged sustainable development.

The following flow chart describes the layout of this project briefly:

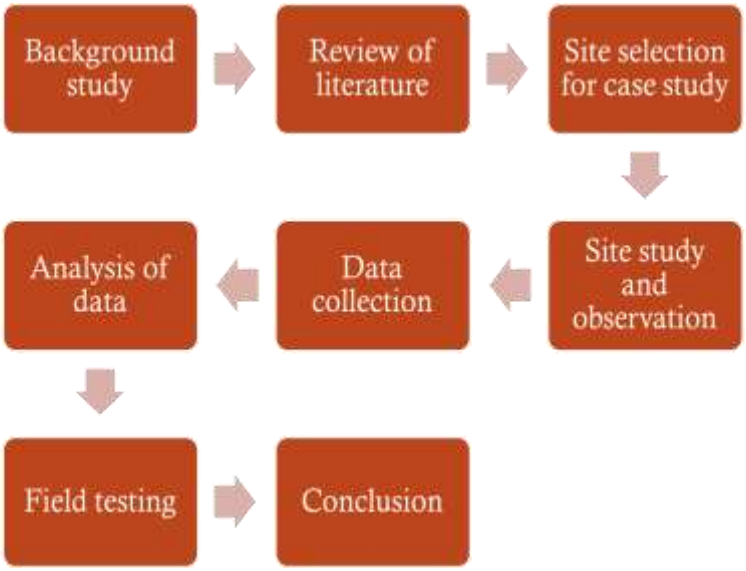

Fig. 1 Flow chart

2.3 Research Gap –

The development rate is very high and the environment is being affected negatively due to this high development rate. Since the resources that we have been consuming since decades are limited there's an urgent need to shift to renewable energy sources and opt in sustainable development. Combining renewable energy sources and development can help in sustainable development. Though people are using solar energy from a long time there are many other ways of using solar energy for electricity generation, thus, reducing the cost of electricity as solar energy costs are lower in comparison.

2.4 Case Study –

The main objective of this study is to encourage sustainable development. For this purpose an old elevated water tank located at Puikhadi, Kolhapur is selected which provides water to households in the city. This water tank is located in the premises of the water treatment plant.

Detailed study of water tank, solar energy generation, solar panels and devices required for electricity generation, electricity required for pumping and its cost comparison is done.

3.4.1 Initial visual examination –

a) Preliminary Inspection:-

Basic Information Gathering: - A program has to be evolved to obtain as much information as possible about the distressed structure and it listed out even though. Many construction details and other related information may not be available, yet as much as information and details as possible to be gathered during the preliminary site visit. Before undertaking a condition survey of a structure, the following essential information is required

i. Period of construction;
ii. Exposure conditions of structure;
iii. Designed use vice-versa present use of structure;
iv. Previous changes in use, if any;
v. Record of structural changes made, if any;
vi. Record of first occurrence of deterioration, if any
vii. Details of repairs, if carried out in the past;
viii. Reports of previous investigations/condition surveys, if any;
ix. Apparent cause of distress, as could be ascertained from the owner/client;
x. Photographs of distressed portions of structure.

b) Visual Inspection:

i. Visual examination of a structure is the most effective qualitative method of evaluation of structural soundness and identifying the typical distress symptoms together with the associated problems.
ii. This provides valuable information to an experienced engineer in regard to its workmanship, structural serviceability and material deterioration mechanism.
iii. It is meant to give a quick scan of the structure to assess its state of general health.
iv. The record of visual inspection is an essential requirement for preparation of realistic bill of quantities of various repair items.

v. Experienced engineers should carry out this work as this forms the basis for detailing out the plan of action to complete the diagnosis of problems and to quantify the extent of distress.

2.4.3 Auditing the structure –

a) Condition Survey**:**

Condition Survey is an examination of concrete for the purpose of identifying and defining areaof distress. While it is referred in connection with survey of concrete and embedded reinforcement that is showing some degree of distress, its application is recommended for all buildings and structures. The system is designed to be used for recording the history of the project from its inception to completion and subsequent life.

b) Information related to repair works

False ceiling, carpets, recently done paints, patch work repairs of plaster, re-plaster etc. are create obstructions to visual inspection. Such areas should be analyzed and recorded with due care. The access height from within and from outside during this inspection could also be a major problem. Notes of these obstructions/limitations of visual inspection need to be recordedfor taking into considerations while preparing the work details on repairs/rehabilitation.

- **Rebound hammer test**

Figure 2 Performing rebound hammer test

The operation of Rebound Hammer (also called Schmidt‘s Hammer) is illustrated in figure below when the plunger of rebound hammer is pressed against the surface of concrete, a spring controlled mass with a constant energy is made to hit concrete surface to rebound back. The extent of rebound, which is a measure of surface hardness, is measured on a graduated scale. This measured value is designated as Rebound Number (a rebound index). A concrete with low strength and low stiffness will absorb more energy to yield in a lower rebound value.

Procedure to determine strength of hardened concrete by rebound hammer:

i. Before commencement of a test, the rebound hammer should be tested against the test anvil, to get reliable results, for which the manufacturer of the rebound hammer indicates the range of readings on the anvil suitable for different types of rebound hammer.

ii. Apply light pressure on the plunger – it will release it from the locked position and allowit to extend to the ready position for the test

iii. Press the plunger against the surface of the concrete, keeping the instrument perpendicularto the test surface. Apply a gradual increase in pressure until the hammer impacts. (Do not touch the button while depressing the plunger. Press the button after impact, in case it is not convenient to note the rebound reading in that position.)

The results affected by the following factors are significantly:

1) Mix characteristics:
   i) Cement type,
   ii) Cement Content,
   iii) Coarse aggregate type
2) Angle of Inclination of direction of hammer with reference to horizontal
3) Member Characteristics,
   i) Mass,
   ii) Compaction,
   iii) Surface type,
   iv) Age, rate of hardening and curing type,
   v) Surface carbonation,
   vi) Moisture Condition,
   vii) Stress state and temperature.

- **Ultra-sonic pulse velocity test**

Ultrasonic test on concrete is a recognized non-destructive test to assess the homogeneity and integrity of concrete. With this ultrasonic test on concrete, following can be assessed: Qualitative assessment of strength of concrete, its gradation in different locations of structural members and plotting the same. Any discontinuity in cross section like cracks, cover concrete delamination etc. Depth of surface cracks.

This test essentially consists of measuring travel time, T of ultrasonic pulse of 50 to 54 kHz, produced by an electro-acoustical transducer, held in contact with one surface of the concrete member under test and receiving the same by a similar transducer in contact with the surface at the other end. With the path length L, (i.e. the distance between the two probes) and time oftravel T, the pulse velocity (V=L/T) is calculated. Higher the elastic modulus, density and integrity of the concrete, higher is the pulse velocity. The ultrasonic pulse velocity depends onthe density and elastic properties of the material being tested. Though pulse velocity is related with crushing strength of concrete, yet no statistical correlation can be applied.

The pulse velocity in concrete may be influenced by:

a) Path length

b) Lateral dimension of the specimen tested

c) Presence of reinforcement steel

d) Moisture content of the concrete

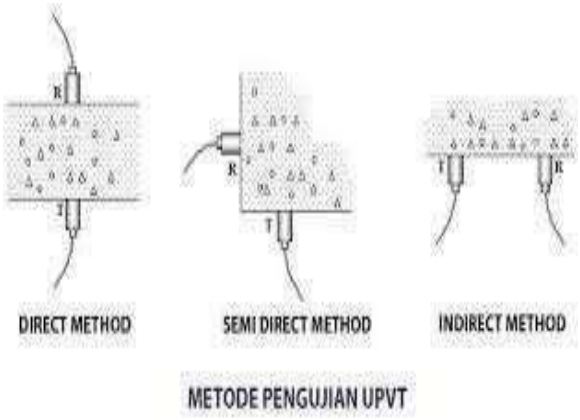

Figure 3Ultra-sonic pulse velocity test methods

Detection of defects –

When ultrasonic pulse travelling through concrete meets a concrete-air interface, there is a negligible transmission of energy across this interface so that any air filled crack or void lying directly between the transducers will obstruct the direct beam of ultrasonic when the void has a projected area larger than the area of transducer faces. The first pulse to arrive at the receiving transducer will have been directed around the periphery of the defect and the time will be longer than in similar concrete with no defect.

- Working of Solar Power Plant

As sunlight falls over a solar cell, a large number of photons strike the p-type region of silicon. Electron and whole pair will get separated after absorbing the energy of photon. The electron travels from p-type region to n-type region due to the action of electric field at p-n junction. Furtherthe diode is reversed biased to increase this electric field. So this current starts flowing in the circuit for individual solar cell. We combine the current of all the solar cells of a solar panel, to get a significant output.

- Design of solar system

We have designed installation of solar power plant system on a top of water tank. The total area of water tank is 789.238 Sq.m.

Table 1 Solar plant installation details

Solar panel	
Size	1 X 2 M
Cost (per head)	9000 RS
Energy	1.3 Unit / Day
Weight	20 to 22 Kg
Solar inverter	
Price	1.5 lac
Capacity of solar inverter	38 KW
Battery	
Price	22000
Number of batteries	91
Fabrication structure	
Price	6000/ Kg
Weight	25-30 Kg (Approximate)

Result and discussion

3.1 Result of rebound hammer test:

Readings of outer and inner columns of the water tank:

Table 2 Rebound hammer test column readings

POINT	STRENGTH (N/mm2)	AVERAGE (N/mm2)
Outer Column		44
1	40	
2	36	
3	46	
4	44	
5	45	
6	56	
Inner Column		
1	40	40
2	40	
3	38	
4	42	
5	40	
6	36	

Readings of retaining wall of water tank:

Table 3Rebound hammer test retaining wall readings

POINT	STRENGTH (N/mm2)	AVERAGE (N/mm2)
1	38	44
2	46	
3	40	
4	40	
5	50	
6	46	

Readings of Beam and slab of water tank:

Table 4Rebound hammer test beam and slab readings

POINT	STRENGTH	AVERAGE
Beam		43
1	48	
2	40	
3	42	
4	44	
Slab of water tank		
1	26	30
2	28	
3	28	
4	32	
5	34	
6	30	

3.2 Ultra-sonic pulse velocity test result:

Table 5 Ultra-sonic pulse velocity test readings

SR. NO.	POINTSs	ULTRASONIC PULSE VELOCITY TEST					
		Structural member	Method of transmission	Path Length in mm	Time in µs	Pulse Velocity (km/sec.)	Concrete Quality Grading
Water Tank							
1	Point-1	Water Tank	Surface	400	110	3.63	Good
2	Point-2	Water Tank	Surface	400	106	3.77	Good
3	Point-3	Water Tank	Surface	400	114	3.50	Good

4	Points-4	Water Tank	Surfaces	40 0	10 2	3.92	Good

Figure 4 Ultra-sonic pulse velocity test

CALCULATIONS:

- Total capacity of water tank = 100000 litres.
- 25 hp motor is presently installed at the site.
- 1hp motor carries 2500 litres of water to the tank; hence, 25hp motor will carry 62500 litres of water per hour.
  Therefore, water flow in 1 minute = 1041.66 litres.
- Therefore, time required to fill 100000 litres tank = 96 minutes.
- For 25hp motor, 18.6KW/h power is required,
  Therefore, power required for pumping water to fill 100000 litres tank = 29.76KW

- Total top area of water tank where panels are to be installed = 789.23 sq.m.
- Size of one solar panel = 2 sq.m.
  Therefore, total number of panels to be installed = 113
- One solar panel produces 1.3KW energy per day,
  Therefore, total energy produced by 113 panels = 146.9KW
- **Power required for pumping water = 29.76KW**
  Therefore, power remaining after pumping = 146.9 - 29.76 = 117.14KW

Remaining power can be utilized for other purposes/requirements on the water treatment plant.

Now,

- Cost of 1KWh electricity in India = Rs. 8.5/-
  Therefore, cost of146.9KW electricity = 146.9x8.5 = Rs. 1248/-
- Total cost of electricity for one month = Rs. 37459/-

Now,

- Total installation cost of panels = 9000x113 = Rs. 1017000/-
- Total cost of inverter = 150000
- Total cost of batteries (91) = Rs. 22000/-
- Total cost of fabrication = Rs.6000/kg = 25x6000 = Rs. 150000/-
  Therefore total installation cost = Rs. 1339000/-
- Total electricity cost for one month = Rs. 37459/-
  cost for one year = Rs. 449508/-
  cost for next 6 years = Rs. 2697048/-

- Cost of solar energy for next year's after installation = Rs. 1339000/-

(6 years is considered as the minimum battery life is 6 years and thereafter only maintenance cost is needed)

Hence, it is cost efficient in long run.

4.1 Conclusion

This particular research of Sustainable Development in construction by generating solar energy using old elevated water tank conducted at water treatment plant puikhadi, Kolhapur shows the benefits of switching to solar energy and increased efficiency of land and the old structure. Due to rapid rate of development the environment is being affected negatively and there is an urgent need to switch to the non-conventional energy sources. This not only helps the environment but also turns out to be economically feasible in the long run. Following are the conclusions:

1. The water tank doesn't need to be reconstructed or demolished except for minor repair works as it has good strength and is fit for solar panel installation.
2. Installation of solar panels on the water tank minimizes the land issues for solar plants.
3. In the long run it turns out to be economically feasible.
4. Minimizes the inconvenience caused during long power cuts.
5. Dependency on conventional electricity is reduced which ultimately help in sustainable development.
6. Solar power generates ample amount of electricity which not only satisfies the need of the plant but the remaining can be used for other purposes too.
7. It is cost efficient in the long run as the total electricity cost in next year's is reduced by 50%

5.2 Future Scope

1. Advanced battery backups can be installed to increase the amount of energy that can be stored.
2. Extra amount of energy stored in the battery backups can be used during rainy seasons as well.
3. Installing rotational solar panels and rotating them as per the position of the sun to store maximum amount of sunlight and utilize it for more purposes.
4. Efficiently making use of outdated old structures in heart of the cities where there is no land for solar installation.
5. Extra energy produced by the solar can be sent further to the power stations.

REFERENCES

[1] Sheila J.H.Alicen, K. Renewable Energy Applications for Existing Buildings.23 September 2011

[2] Smita, K. Kenneth, I.; Marco, P.; Arman, H. Potential and Impact of Incorporating Roof Photovoltaic to Enhance Environmental Sustainability of Historic English Churches in the United Kingdom. In IOP conference Series: Earth and Environmental Science; IOP Publishing: Bristol, UK, 2019

[3] Murgul V Vera, M. Solar energy systems in the reconstruction of heritage historical buildings of the northern towns.