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Application of Total Quality Management of Retrofitting Techniques

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ABSTRACT

The word retrofit means to apply new technologies to an older system. Retrofit is process by adding some new features that were not there before. Retrofitting in construction industry refers to re-strengthening of existing structure to make them seismic resistant. Retrofitting is a technique to improve the structural capacities including the strength, stiffness, ductility, stability of a building that is found to be deficient. In rural side of Pune, most of the residential buildings have been designed only for dead and live loads. Since Pune lies in zone III, the buildings located in this zone needs to be seismic resistant. Seismic retrofitting is necessary in case of any damages in high seismic prone area. The main objective of this thesis is to study various methods used for rehabilitation repairs and retrofitting in construction industry that includes new construction techniques and traditional construction techniques, to minimize retrofitting costs and waste without affecting production & quality and to minimize environmental effects. This study includes visual inspection and advance technique to rehabilitation repairs and retrofitting survey in which we can find out the factor affecting the repair cost which directly related with material use in retrofitting. The factors affecting the retrofitting cost and time were identified through the literature based on previous research. The comparison of time for both material used in retrofitting work in each material showed that the material which includes advanced method, new techniques, installation process is the most suitable alternative to the existing traditional method like cement slurry.

Keywords: Retrofitting, Seismic retrofitting, rehabilitation repairs, Strength, TQM,

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I. INTRODUCTION

Existing concrete structures may be found to perform unsatisfactorily for a variety of reasons. This could manifest itself by poor performance under service loading, in the form of excessive deflections and cracking, or there could be inadequate ultimate strength.

India is one of the most earthquake prone countries in the world and the recent devastation caused due to earthquake has exposed the seismic vulnerability of structures in our country. In rural side of Pune, most of the residential buildings have been designed only for dead and live loads. Since Pune lies in zone III, the buildings located in this zone needs to be seismic resistant. About 50-60% of the total geographical area comes under earthquake prone region. Almost, 4 out of 5 structures are non-engineered made up of earthen walls, stone walls, brick masonry walls etc. Seismic retrofitting is the modification of existing structures to make them more resistant to seismic activity, ground motion, or soil failure due to earthquakes. These structures cannot even sustain earthquake of minor intensity and result in heavy loss of life and property. The building sector contributes a large proportion of the world's total final energy consumption. As a result, considerable attention has been paid to energy efficiency in the building sector. At the current stage, building retrofitting is the most feasible and cost-effective method to improve building energy efficiency. This paper presents a multi-objective optimization model for life-cycle cost analysis and retrofitting planning of buildings.

Steps of retrofitting

1. Determine as accurate as possible how the building behave when shaken by an earthquake
   - check the building
   - check building material quality
   - list all component of the building that are damaged

1. Perform a dynamic analysis for the building to get an idea of the causes of damage and determine the load paths when shaken by the earthquake.
2. Determine the causes of damage of components; caused by shear, compression, tension, flexure, anchoring, etc.
3. As soon as the type of damage can be identified, repair and restoration of the
4. Components can be done separately in order that the original strength of the components can be restored.
5. If results of analysis indicate that the building with restored components can withstand the maximum expected

earthquake for that area based on the latest code, then there is no need to strengthen.
6. However, if the building with restored components was not designed or designed for a lower than the maximum expected earthquake Specified by the latest code, then the building needs to be strengthened
7. For strengthening, the restored building must be re-analyzed to identify which component must be strengthened.
8. For engineered buildings with severe damage and if the building needs to be strengthened, 3d non-linear analysis performance based design should be done.
9. If cost for strengthening the building to its original function is not feasible, one option that can be chosen is to change the building function with less stringent requirement, therefore cost will be reduced.
10. After the strengthening works is completed, the building must be re-analyzed to ensure that the strengthened building is earthquake resistant.

Stages of repair

The various stages for the repair of concrete structures are as follows:

a) Removal of damaged concrete
b) Pre-treatment of surfaces and reinforcement
c) Application of repair materials
d) Repair Procedure

a) Removal of damaged concrete

- Before the execution of repair in any structure, one most important factor is to remove the damaged concrete.
- The equipment and tools used for the removal of damaged concrete mostly depend on the damage.
- Damaged concrete are normally removed by using hand tools sometimes it is impossible to use hand tools then it can be removed with a light or medium weight air hammer fitted with a spade shaped bit.
- Care should be taken while removing the damaged portion that it must not damage the unaffected concrete portions.

b) Pre-treatment of surfaces and reinforcement:

It involves the following steps:

- Unsound material must be completely removed.
- Undercutting along with the formation of smooth edges.
- Surface cracks must be removed.
- Formation of a well-defined cavity geometry with rounded inside corners.
- Uniform surface but rough for repair can be provided.
- Before the repair, dirt, oil and all other loose particles should be removed out from the cavities. It can be accomplished by blowing with compressed air, hosing with water, acid etching, wire brushing, scarifying or a combination. Brooms or brushes will also help to remove loose material.

Application of repair materials

When the concrete surface is prepared, a bonding coat such as cement slurry, epoxy, resin materials etc. must be applied to the whole exposed surface which was cleaned before without any delay

c) Repair procedure

The repair of any damaged structure can be discussed under two categories such as: ordinary or conventional procedures; and sometimes using special procedures including the latest techniques and newer materials. It must be done with one or more objectives which are as follows:

- To increase the strength
- To improve the performance of structure.
- To provide water tightness.
- To improve appearance of concrete surface.
- To improve durability.
- To prevent access of corrosive materials to reinforcement.

Repair Materials

Cement and steel are generally used for the repair of various types of damages. Besides these, some special materials and techniques are available for best results in the repair works. They are described below:-

- ✓ Shotcrete
- ✓ Epoxy resins
- ✓ Epoxy mortar
- ✓ Gypsum cement mortar

Quick setting cement mortar

- ✓ The success of repair activity depends on the identification of the root cause of the deterioration of the concrete structures.
- ✓ If this cause is properly identified, satisfactory repairs can be done for the improvement of strength and durability, thus extending the life of the structure, is not difficult to achieve.
- ✓ Earthquake creates great devastation in terms of life, money and failures of structures.
- ✓ Earthquake Mitigation is an important field of study from a long time now.
- ✓ Seismic Retrofitting is a collection mitigation technique for Earthquake Engineering.
- ✓ It is of utmost importance for historic monuments, areas prone to severe earthquakes and tall or expensive structures.

Total Quality Control

Quality control in construction typically involves insuring compliance with minimum standards of material and workmanship in order to insure the performance of the facility according to the design.
These minimum standards are contained in the specifications described. For the purpose of insuring compliance, random samples and statistical methods are commonly used as the basis for accepting or rejecting work completed and batches of materials. Rejection of a batch is based on non-conformance or violation of the relevant design specifications. Materials obtained from suppliers or work performed by an organization is inspected and passed as acceptable if the estimated defective percentage is within the acceptable quality level.

At defined intervals top management should review the adequacy and performance of the QMS to ensure that GMP and regulatory requirements, ISO quality management principles and quality manual claims are being routinely satisfied. The measures listed above and other sources of relevant information such as product reviews and external inspections should be used. This information can be used to realign resources in order to improve the QMS. Another application of data analysis is in the control of processes. Appropriate statistical techniques should be identified, documented and implemented to control quality critical processes.

Aim

"We have investigated economic aspects of material used in retrofitting work. A structure of repair costs was proposed for the evaluation of management for total quality Management."

Objectives

- To look at the restore and retrofitting using entire best control.
- To studies opportunity and conventional creation strategies used for repairs, and retrofitting. Compare to best Management.
- To Improve Total best control strategy to lessen retrofitting costs, waste, and environmental impact.
- To discover impact on general restore value and blessings the usage of superior cloth and enhance creation strategies.

Problem Statement

"To carry out at the diverse retrofitting strategies and to examine on flexure retrofitted RC beams the usage of conventional approach on TQM."

To examine the impact of sew intensity on flexure wearing ability of flexure poor beams via way of means of retrofitting with sewing additionally impact on general rehabilitation restore value and blessings the usage of superior cloth and enhance creation strategies.

II. RESEARCH METHODOLOGY

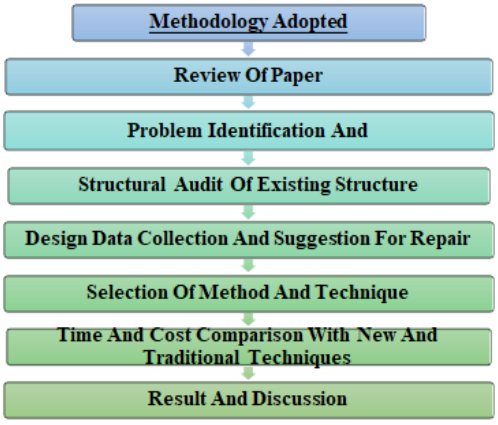


Figure1.1: Methodology Flow

CASE STUDY

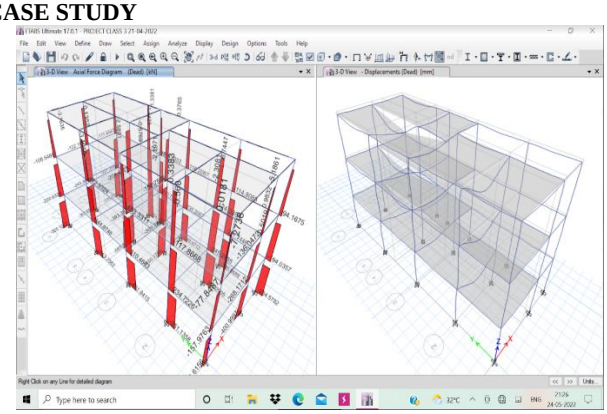
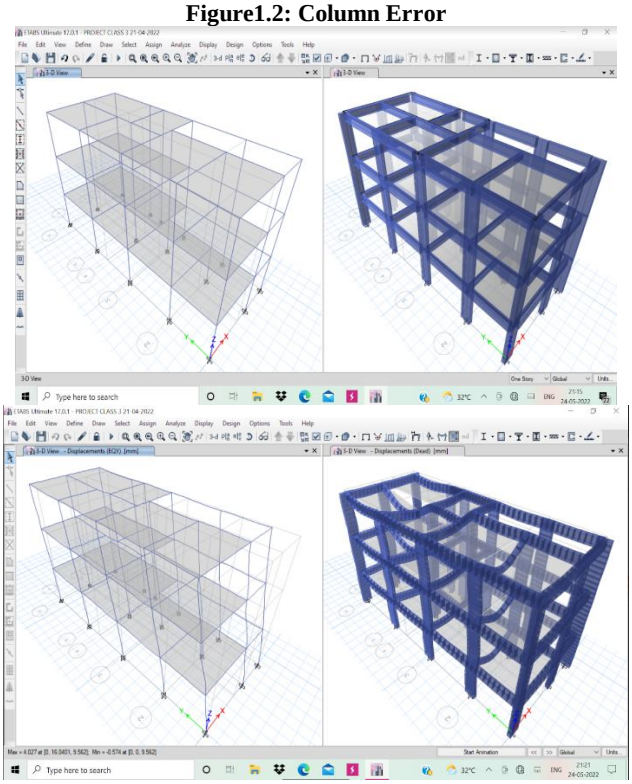
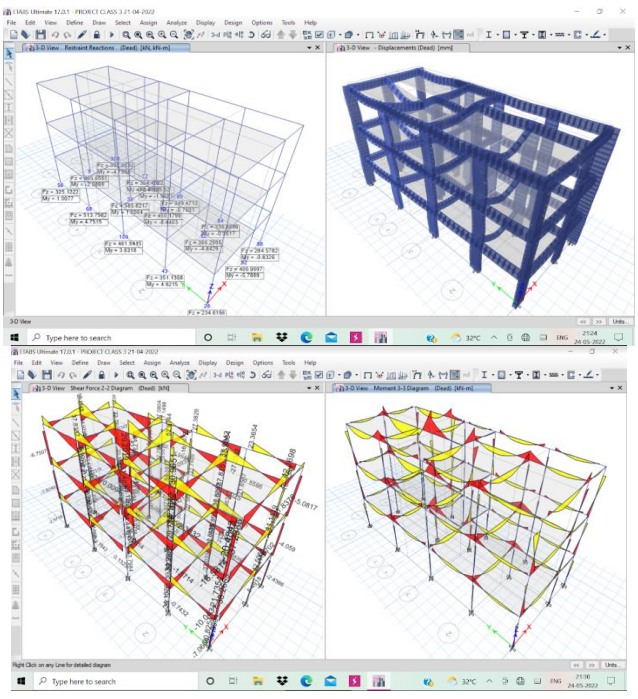
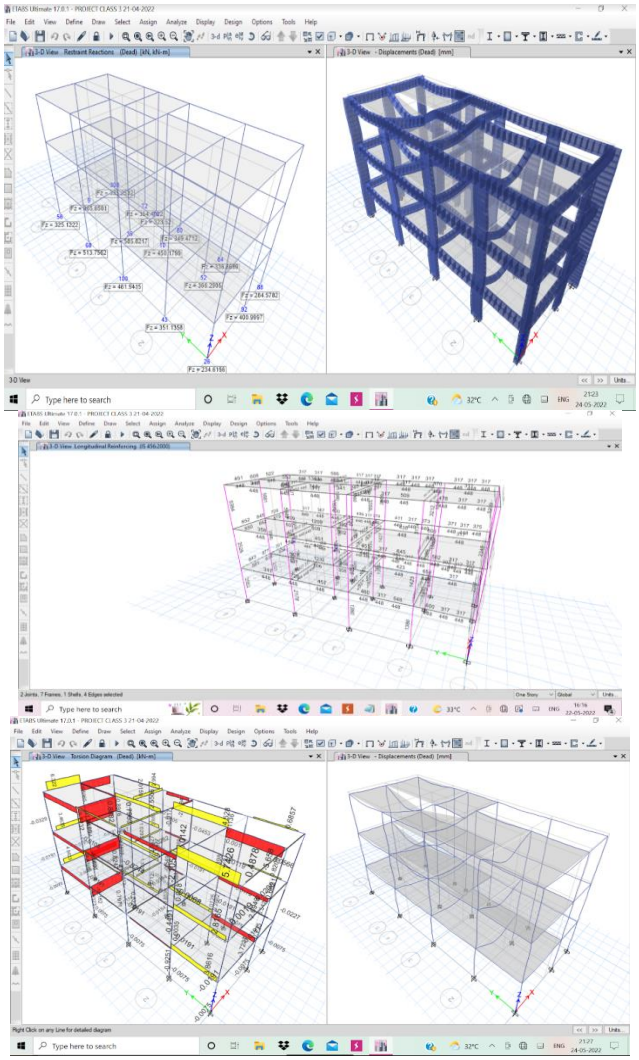


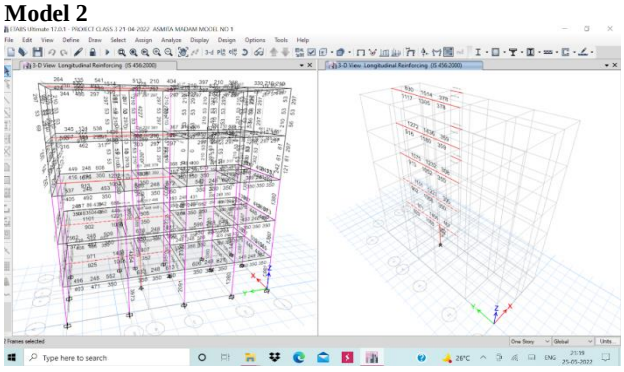
Figure1.2: Column Error



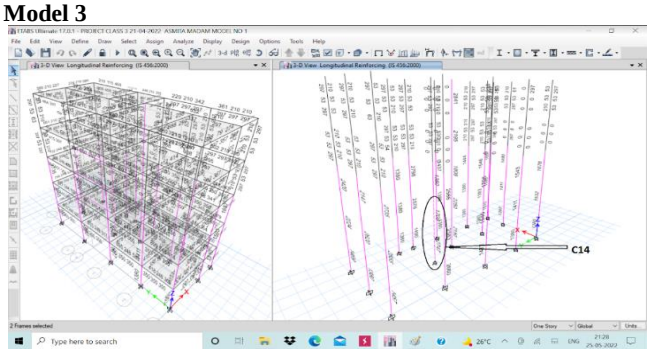




Model 2



Model 3



What Is Retrofitting?

Retrofitting is the approach of enhancing or repairing some thing after it's been manufactured. Retrofitting paintings consists of converting or repairing the shape gadget of a constructing after its creation and occupation. This paintings outcomes in multiplied protection and sturdiness of the shape. Retrofitting of homes is needed for houses which might be tormented by disasters and harm through seismic forces. Retrofitting completed for your own home makes it immune to seismic pastime because of earthquakes. Retrofitting of systems way making adjustments to an present constructing to guard it from flooding or different dangers including excessive winds and earthquakes.

Retrofitting of RCC structural contributors is finished to regain the energy of deteriorated structural concrete elements. The energy deficiency of concrete structural contributors may be because of negative workmanship, layout errors, and deterioration because of the aggression of dangerous agents. The major purpose of retrofitting is to stabilize the contemporary shape of homes and lead them to earthquake resistant.

Methods of Retrofitting of Building

The following are the most common method of retrofitting a building

1. Adding New Shear Wall
2. Adding Steel Bracing
3. Wall Thickening Technique
4. Base Isolation Technique
5. Mass Reduction Technique
6. Jacketing Method
7. Fiber Reinforced Polymer (FRP)
8. Epoxy Injection Method
9. External Plate Bonding

Adding New Shear Wall:

This is a frequently used technique for retrofitting of building of non-ductile reinforced concrete frame buildings. The elements can be either cast-in-place or pre-cast concrete elements. New elements preferably are placed at the exterior of the building. This method id not preferred in the interior of the structure to avoid interior moldings.

Adding Steel Bracing

Retrofitting by Steel Bracing Support
Steel bracing is an effective solution in the retrofitting of building when large openings are required. Potential advantages due to higher strength and stiffness and opening for natural light can be provided. The amount of work is also less so foundation cost may be minimized and adds much less weight to the existing structure.

Wall Thickening Technique
The existing walls of a building are added a certain thickness by adding bricks, concrete, and steel aligned at certain places as reinforcement. The weight of the wall increases and it can bear more vertical and horizontal loads. Also, it is designed under special conditions that the transverse loads do not cause sudden failure of the wall. Rust can be developed on reinforcement if not covered properly by mortar.

B**ase Isolation Technique**

Base Isolation
Isolation of superstructure from the foundation is known as base isolation. It is the most powerful method for passive structural vibration control techniques. When building isolates from the ground it causes lesser seismic loads, hence lesser damage to the structure and minimum repair of the super–structure.

The main demerit of this method is, it cannot be applied to structures like other retrofitting and expensive in the budget.
This method is inefficient for high rise buildings and not suitable for buildings rested on soft soils.

Jacketing Method

Column Beam Jacketing
It is most used method of retrofitting of building.
Jacketing is the most popularly used method for the strengthening of columns and beams of a building.
Jacketing consists of added concrete with longitudinal and transverse reinforcement around the existing columns.
It improves the axial and shear strength of the column and major strengthening of the foundation may be avoided.
The amount of work is less as foundation strengthening does not require and increases the shear strength of the column. It also increases the confinement of concrete in circular columns.
Steel jacketing does not increase the significant weight of the column and also saves construction time.

Fiber Reinforced Polymer (FRP) for Retrofitting of Building

An axial strengthening system is a fiber–reinforced polymer that is used to improve or enhance the capacity of reinforced concrete beams.
It can be used for both circular and rectangular-shaped columns, but the former is more effective.
FRP improves the shear capacity of reinforced concrete elements and increases the ultimate load-carrying capacity of reinforced concrete members. In addition, the ductility of a reinforced concrete column is greatly improved. Because all resins and some fibers absorb moisture, the composite must be dried before repair.

Epoxy Injection Method

External Plate Bonding

External Plate Bonding for Column and Beam Repair

Strength of Strengthening of reinforced concrete beams with external plates or strips is a conventional method and has been utilized for many decades.
The external plate bonding method can be used for increasing the shear strength of reinforced concrete beams by completely or partially wrapping steel plates at the joint of a column and beam.
An external plate providing perpendicular to potential shear cracks is effective to increase the shear the concrete reinforced member.
The additional shear strength is achieved, but depending on beam geometry, existing concrete strength, and applied the wrapping method.

Enlarging Reinforcing Method

Section-Enlarging Reinforcing Method
The enlarged cross-section method is used to increase the components of the reinforcement area, which enhance the bearing capacity and also increase its cross-section stiffness and change the natural frequency of vibration. This method is widely used in the reinforced concrete structure of the beam, slab, column, etc. The enlarged cross-section method is suitable for the reinforcement of reinforced concrete bending and compression member.
Factors Affecting in Selection of Retrofitting of Building Methods
The following factors should be kept in mind while selecting a method of retrofitting for building:

- Existing concrete strength.
- Accessibility to work areas.
- The magnitude of strength to be enhanced.
- Cost of construction and maintenance.
- Time constraints.
- Clearance issues.
- Seismic effect consideration.
- Environmental aspect.

Identify the Structural Damages and Their Retrofitting Process

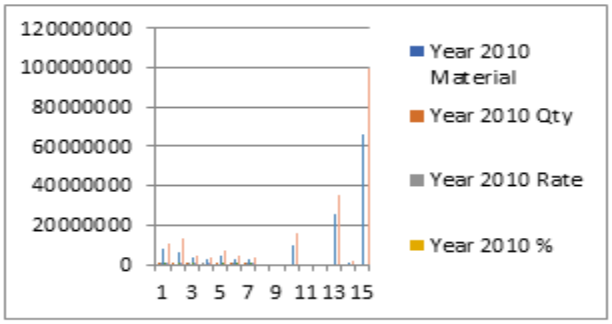
Retrofitting of Corroded Structural Member
If corrosion has started, the following process is adopted: Remove weak concrete and expose reinforcement all around.. Clean the rust of steel by wire brushes or sandblasting.

- Apply rust removers and rust preventers.
- Reinforce to supplement rusted steel if required with anchorage i.e. shear connectors.
- Apply tack coat or bonding coat (to provide a bond between the old concrete and new concrete) of polymer and epoxy resin-based bonding material. Use one of the patching techniques to restore concrete to the original surface level. Polymer defined mortars are very good. This can be used with or without guiniting.
- Injection of cement slurry or polymer–modified slurry or epoxy to fill up pores or internal cracks or honeycombing.
- Apply a suitable protecting coating.

Retrofitting of Severely Damaged Concrete:
In case when the original concrete is in very bad condition and the injection of grouting is not able to rehabilitate the section to take the required loading, RCC Jacketing of the concrete section is to be provided.

floors building with each of 2 Bhk flat of Area 1200 square feet

		Year 2010				Year 2021/22		
Sr. no	Material	Qty	Rate	%	Amount	Qty	Rate	Amount
1	Cement (bag)	28800	270		77,76,000	28800	365	1,05,12,000
2	Steel (kg)	160000	40		64,00,000	160000	85	1,36,00,000
3	Sand (brass)	832	4000		33,28,000	832	5000	41,60,000
4	Gravel(brass)	928	2900		26,91,200	928	3500	32,48,000
5	Brick(nos.)	512000	8		40,96,000	512000	14	71,68,000
6	Tiles (sq. ft.)	57600	50		28,80,000	57600	70	40,32,000
7	Color (liters)	9600	250		24,00,000	9600	350	33,60,000
8	Window							
	Door							
	Plumbing				96,00,000			1,60,00,000
	Electric							
	Sanitary							
9	Labour				25600000			3,52,00,000
10	Engineer fees plan & design				1280000			1920000
					6,60,51,200			9,92,00,000



Graph1.1: Cost Analysis of old and new material based

JACKETING

The cost of CFRP is large as compared to steel and RC jacketing.
The cost of RC jacketing

= cost of (cement+ FA+ CA+ fly ash + Reinforcement) = (1 bag× RS 360) +
(228kg÷1493.56×RS882) + (194kg÷1476×RS2258) + (10kg×RS10) + (1200) = RS2500/-(Labor cost=300/-) = 2800/-

The cost of steel jacketing = cost of steel plates= RS 3000/-

The cost of CFRP jacketing= cost of (CFRP sheet) + (epoxy resin) (3500+3500+3500) +(400/kg×5) =RS 12500/-

RC jacketing 2500/- or 2800/- Steel jacketing 3000/- CFRP jacketing 12500/-

Provide the essential supporting system to the structure.

- Remove weak concrete.
- Clean the surface and clean the corroded part of the steel.
- Apply rust removers and rust preventers.
- Provide additional steel all around the structure.
- Provide required formwork.
- Provide a polymer–based bonding coat between old and new concrete surfaces.
- Place the concrete of required thickness, grade, and workability admixed with different admixtures.
- The benefit of Retrofitting of Building:

The followings are the benefits of the retrofitting of building technique:

This technique is used to prevent displacement from the concrete foundation of the structure. It improves the stability and safety levels of the structure. Retrofitting buildings are more adaptable and suitable for existing activities or future activities and making a building more comfortable to resist loading. Helps to prevent damage to the structure and injury to the occupants Retrofitted buildings are more energy–efficient and lower carbon emissions from the building operations. The process helps to improve a residence's ability to keep residents safe when there is an earthquake. Retrofitting also helps to make homes more habitable after any major earthquake. Also, when you get retrofitting done in your home, most insurance companies have increased their insurance benefits.
Increasing the local capacity of the structural and non-structural components

Demerits of Retrofitting of Building

Other than the advantages, retrofitting also has several disadvantages, such as: The skill of the worker must be complying with the adopted retrofitting approaches Limited access to the construction site, since the building could be still in function. Difficult of bonding mat be arise between old masonry and the new concrete surface. Concrete has higher strength than old masonry structure, thus special care should be given to specify the strength of overlaid concrete.

III. CONCLUSION

We have investigated economic aspects of both material used in retrofitting work. A structure of repair costs was proposed for the evaluation of management scenarios. The comparison of time for both material used in retrofitting work in each material showed that the material which includes advanced method, new techniques, installation process is the most suitable alternative to the existing traditional method like cement slury.
The case study demonstrates that construction materials contribute to the generation of large quantities of waste so we study to reduce the waste and improve the quality.
To solve Waste minimisation is common in the project site where 52.54% of the waste material is reused and recycled. Waste minimisation is economically feasible and also plays an important role for the improvement of environmental management and quality management.
The net benefit of reusing and recycling of waste materials is estimated at 3.7% of the total project budget. Thus, the construction industry can save money by implementing Quality practices on the site
Construction industry efforts to improve quality have been slow and fragmented as well as being fraught with difficulties in implementing.
This also due to the characteristics of the construction industry and its dynamic project processes. For QMS implementation and an approach such as to be a real solution, all levels of a company's structure need to be bound by a strong commitment towards it and factors majorly effect on the time of execution phase like

- Factor
- Labour Cash Flow
- Weather Conditions
- Material Availability

In the construction quality systems and organizational culture area endorse this view by revealing that quality culture and corporate culture are considered to be determinant factors in contributing to the successful or unsuccessful implementation and maintenance of a quality system.

Studies examining the effects of QMS implementation in the construction industry show that not only do customers benefit substantially from it, but so does the construction company

IV. ACKNOWLEDGMENT

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