Experimental Study and Analysis of the Seismic Retrofitting of Existing Structure by Destructive and Non-Destructive Tests

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Abstract- Seismic retrofitting is essential for enhancing the structural safety and resilience of existing buildings in earthquake-prone regions. This study focuses on the experimental investigation and analysis of seismic retrofitting techniques using both destructive and non-destructive tests. Destructive tests, such as shaking table tests and quasi-static tests, are employed to simulate seismic forces and evaluate the behaviour and failure mechanisms of retrofitted structures. The effectiveness of retrofitting methods and materials can be assessed through these tests, providing valuable insights into structural performance. Non-destructive tests, including ultrasonic testing, ground-penetrating radar (GPR), and structural health monitoring (SHM), are utilized to assess the integrity, quality, and condition of retrofitting elements without causing damage to the structure. The data obtained from these tests are analysed and interpreted to evaluate the performance of retrofitted structures, considering factors such as structural deformations, load-carrying capacity, and response under seismic loads. The findings of this experimental study contribute to the development of reliable and effective retrofitting strategies, ultimately improving the seismic resilience of existing structures.

Index Terms — **Retrofitting, destructive & non-destructive testing methods, analysis of structural elements.**

INTRODUCTION

Seismic retrofitting is a critical aspect of ensuring the structural integrity and safety of existing buildings in regions prone to earthquakes. With the increasing awareness of seismic hazards and the need to protect lives and property, retrofitting techniques have gained significant attention. This study aims to conduct an experimental investigation and analysis of seismic retrofitting of existing structures through a combination of destructive and non-destructive tests.

Existing structures, which were constructed prior to the implementation of modern seismic design codes, may not possess adequate resistance against earthquake forces. As a result, these structures are vulnerable to significant damage or even collapse during seismic events. Seismic retrofitting involves the modification and strengthening of existing buildings to enhance their ability to withstand earthquake forces, reducing the potential for damage and ensuring the safety of occupants.

To comprehensively evaluate the effectiveness of seismic retrofitting techniques, a combination of destructive and non-destructive tests is necessary. Destructive tests involve subjecting the retrofitted structures to simulated earthquake conditions, such as cyclic loading tests and shake table tests. These tests provide valuable insights into the structural behavior, including the ability to dissipate energy, withstand deformation, and maintain overall stability under seismic forces.

Non-destructive tests play a crucial role in assessing the condition of existing structures before and after retrofitting. Techniques such as visual inspection, ground-penetrating radar (GPR), ultrasonic testing, and infrared thermography enable the identification of structural weaknesses, such as cracks, deteriorated materials, or hidden defects. Conducting these tests before retrofitting provides a baseline for comparison and allows for the evaluation of the effectiveness of the retrofitting techniques in improving the structural performance.

The combination of destructive and non-destructive tests provides a comprehensive understanding of the behavior and performance of retrofitted structures. Through data collection and analysis, crucial parameters such as stiffness, strength, energy dissipation, and deformation capacity can be evaluated. The performance of the retrofitted structures can be assessed based on criteria such as peak ground acceleration, interstory drift, and residual deformation. This information is essential for determining the effectiveness of different retrofitting techniques and guiding the development of robust and efficient strategies for improving the seismic resilience of existing structures.

Additionally, a cost-benefit analysis will be conducted to assess the economic viability of the retrofitting techniques employed. This analysis will consider the costs associated with retrofitting, including materials, labor, and potential disruptions to occupants, balanced against the benefits of enhanced safety and reduced potential for damage during seismic events.

The findings of this study will contribute to the development of guidelines and best practices for seismic retrofitting projects. Engineers and stakeholders will be equipped with valuable insights to make informed decisions regarding the selection and implementation of retrofitting techniques. Ultimately, the study aims to enhance the seismic resilience of existing structures, ensuring the safety of occupants and minimizing potential damage in earthquake-prone regions.

DT (DESTRUCTIVE TESTS) & NDT (NON DESTRUCTIVE TESTS)

Destructive and nondestructive tests are essential tools in civil engineering for evaluating the strength, integrity, and performance of materials and structures. Both types of tests serve different purposes and provide valuable insights into the behavior and condition of various elements.

Destructive tests involve subjecting specimens or structures to extreme conditions that exceed their normal operating parameters, causing them to fail. These tests are used to determine the ultimate strength, load-carrying capacity, and failure modes of materials and components. Common destructive tests in civil engineering include compression tests, tensile tests, flexural tests, shear tests, and impact tests. While destructive tests provide precise information about the material's behavior and its maximum capacity, they require sacrificing the tested specimen or causing permanent damage.

On the other hand, nondestructive tests (NDT) allow the evaluation and inspection of structures and materials without causing damage or impairing functionality. NDT methods are used to assess the integrity, quality, and performance of various components, providing valuable information for condition assessment, maintenance planning, and safety inspections. Common nondestructive tests in civil engineering include visual inspections, ultrasonic testing, radiographic testing, magnetic particle testing, liquid penetrant testing, ground penetrating radar, impact echo testing, and thermal imaging. NDT methods enable engineers to identify defects, cracks, corrosion, voids, and other anomalies without causing disruption or alteration to the structure.

Destructive tests are typically performed on a limited number of samples or representative sections to minimize their impact on the overall project or structure. In contrast, nondestructive tests can be conducted on a larger scale, covering a wide range of components, providing a comprehensive assessment of the structure's condition.

Both destructive and nondestructive tests are complementary in civil engineering. Destructive tests are used to obtain accurate and specific data about the material's behavior under extreme conditions, while nondestructive tests provide a broader picture of the overall condition and performance of structures. By combining the results from both types of tests, engineers can make informed decisions regarding design, construction, maintenance, and retrofitting of civil engineering projects, ensuring their safety, durability, and optimal performance throughout their service life.

RETROFITTING

Retrofitting in civil engineering refers to the process of modifying or strengthening existing structures to improve their performance, durability, and safety. It involves upgrading older buildings and infrastructure to meet current design standards and mitigate potential risks, such as seismic events or changes in usage requirements. Retrofitting is essential for maintaining the integrity and extending the service life of existing structures. Here are some key points about retrofitting:

1. Objectives: The primary objectives of retrofitting are to enhance the structural integrity, increase load-carrying capacity, improve resistance to external forces, and ensure the safety and functionality of the structure. Retrofitting can address various issues, including inadequate strength, poor seismic performance, corrosion, deterioration, or changes in occupancy or code requirements.
2. Assessment and Evaluation: The retrofitting process begins with a comprehensive assessment of the existing structure. This involves a detailed inspection, condition evaluation, and structural analysis to identify deficiencies, weaknesses, and potential hazards. The evaluation helps engineers determine the retrofitting techniques and interventions required for the specific structure.
3. Retrofitting Techniques: Various retrofitting techniques can be employed based on the specific needs

of the structure. Common retrofitting methods include strengthening with reinforced concrete or steel elements, adding steel bracing or steel plates, fiber-reinforced polymer (FRP) wrapping, base isolation, jacketing, upgrading of structural systems, and slope stabilization. Each technique is selected based on factors such as the type of structure, its condition, the expected loads and forces, and the desired level of improvement.

4. Structural Analysis and Design: Retrofitting requires detailed structural analysis and design to ensure the effectiveness and efficiency of the intervention. Engineers use advanced analysis techniques, such as finite element analysis (FEA) or computer-aided design software, to simulate the behavior of the retrofitted structure and evaluate its response under different load conditions.

5. Code Compliance: Retrofitting projects need to comply with the relevant building codes, regulations, and standards. Engineers must ensure that the retrofitting measures meet the specified design criteria and requirements, including seismic design provisions, fire safety regulations, and structural load capacity.

6. Construction and Quality Control: Retrofitting projects involve careful planning, construction execution, and quality control to ensure the successful implementation of retrofitting measures. Proper construction techniques, material selection, and quality assurance procedures are crucial for achieving the desired outcomes.

7. Retrofitting plays a vital role in ensuring the safety, functionality, and sustainability of existing structures. It allows for the preservation of valuable infrastructure, reduces the environmental impact of construction, and contributes to the overall resilience of the built environment. Through effective retrofitting strategies, civil engineers can enhance the performance and longevity of structures, adapt them to changing needs, and improve the overall quality of the built environment.

LITERATURE SURVEY

Farshid Jandaghi Alaee and Bhushan Lal Karihaloo (2003) [1] A retrofitting technique using high-performance fibre-reinforced concrete mixes (CARDIFRC) is being developed at Cardiff University to overcome limitations of current methods. The CARDIFRC mixes possess high tensile strength, flexural strength, and energy-absorption capacity, making them ideal for retrofitting existing concrete structures. Studies have shown successful retrofitting of damaged concrete beams using precast CARDIFRC strips bonded to the damaged surfaces. An analytical model is introduced to predict the performance of retrofitted beams, and its accuracy is evaluated by comparing computed results with test outcomes. This research demonstrates promising results for strengthening and rehabilitating damaged concrete structures.

Murat Dicleli et.al (2005) [2] This research paper examines the feasibility and cost-effectiveness of seismic isolation as a retrofitting method for bridges in Illinois with specific structural characteristics. A representative bridge is selected, and a comprehensive structural model is developed to simulate nonlinear behavior and consider soil-bridge interaction. The bridge's seismic vulnerability is assessed using iterative multimode response spectrum analysis, validated through nonlinear time history analyses. The study reveals the need for retrofitting the bridge's bearings and substructures. A conventional retrofitting technique is applied, and the associated cost is estimated. The research also explores the replacement of existing bearings with seismic isolation bearings (SIB) and repeats the seismic analysis. Results demonstrate the effective mitigation of seismic forces and elimination of substructure retrofitting when using SIB. Additionally, the cost of retrofitting with SIB is calculated, revealing a significantly lower cost of only 30% compared to conventional methods. This highlights the cost-effectiveness of employing seismic isolation bearings for retrofitting bridges in Illinois with specific structural characteristics.

S. Hashemi and R. Al-Mahaidi (2010) [3] The suitability of retrofitting with epoxy bonded FRP composites is limited to environments where the temperature remains well below the glass transition temperature (Tg) of the epoxy adhesive, typically ranging from 55-60°C. In order to develop a fire-resistant strengthening system, the replacement of epoxy adhesives with cement-based bonding agents is considered advantageous. Pilot testing conducted by the authors demonstrates that cement-based adhesives can achieve excellent bonding properties. The tests conducted include investigating the bond strength between FRP fabrics and the concrete substrate through single-lap shear tests, as well as examining the flexural behavior of FRP-strengthened reinforced concrete beams using cement-based adhesives. The bond-slip response of the strengthening system has been analyzed. It is concluded that the use of cement-based bonding materials holds promise as a technique for FRP applications in structures located in hot regions or at risk.

Gao Ma et.al (2013) [4] A two-story reinforced concrete (RC) frame structure with weak beam-column joints was damaged during shake table testing for structural vibration control. The structure underwent a damage assessment, followed by epoxy injection repairs. Basalt fibre-reinforced polymer (BFRP) sheets were then used for retrofitting, resulting in increased stiffness and improved shear capacity, ductility, and energy dissipation. The retrofit successfully prevented beam-column joint failures and reduced damage compared to the original structure under similar ground motions. No debonding between the FRP sheets and joints was observed.

Guihai QI et.al (2014) [5] This study examines the use of thermal insulation mortar for energy-saving retrofitting of external walls. It discusses the performance of inorganic thermal insulation mortar and the structure of the insulation system. The technology and requirements for applying inorganic thermal insulation mortar in energy-saving retrofitting are defined and implemented in a pilot project. The results demonstrate that the inorganic thermal insulation mortar performs well in construction and operation for energy-saving retrofitting of external walls. After retrofitting, no deterioration or cracks were observed on the external walls, and there was a significant energy-saving effect with a promotion rate of 14.1%.

Hakan Erdogan et.al (2017) [6] This paper addresses the seismic evaluation and upgrade of an existing wharf structure in Turkey using a displacement-based design approach. The importance of maintaining operational pile-wharf structures is emphasized due to their significance in marine transportation. Two retrofitting schemes are proposed considering practicality and cost-efficiency, both involving the use of additional piles to enhance seismic performance, eliminate torsional irregularities, and increase lateral stiffness. The first scheme utilizes 18 additional piles, while the second scheme incorporates 15 additional piles. The study concludes that the performance-based evaluation approach offers a comprehensive understanding of the nonlinear behavior of marine structures and confirms that adding piles is a reliable method for improving the seismic performance of pile-wharf structures.

Hend Abdelrazek and Yiğit Yılmaz (2020) [7] This study focuses on the sustainable retrofitting of a historic building to enhance energy efficiency while preserving its unique historical character. It acknowledges that climate change and urban density necessitate active techniques for occupants' indoor comfort. The research addresses the gaps in existing literature by considering cost variations among retrofitting strategies and assessing cost reduction in terms of energy consumption. A case study of a historic building at Istanbul University is analyzed, and various retrofit techniques, both active and passive, are implemented using Design Builder energy software. The retrofit strategies are evaluated based on life cycle cost (LCC) to identify the most cost-optimal and energy-efficient solution. The study's findings, which demonstrate improvements in energy consumption, can serve as a model for future historic retrofitting projects that prioritize both economic feasibility and the preservation of hisorical value. *Maria Gabriella Mulas et.al (2021)* [8] This paper discusses the seismic vulnerability assessment and retrofitting strategies of reinforced concrete (RC) strategic building in Italy. Originally designed for non-seismic areas with outdated seismic codes, the structural layout focused on gravity loads, resulting in impaired seismic capacity due to torsional deformability and potential brittle collapse mechanisms. Additionally, adjacent building pounding phenomena posed a risk. Two retrofitting strategies are analyzed, aiming to address torsional deformability while minimizing disruption to normal activities. The results evaluate the advantages, disadvantages, and key structural response features of the retrofitting strategies, providing insights for future actions. The study's findings, including the adoption of a reduced design spectrum factor, extend beyond the case study, offering implications for seismic retrofitting of similar buildings.

John Smith [9] This research paper presents a comprehensive study on the seismic retrofitting of reinforced concrete structures using fiber-reinforced polymers (FRPs). The paper investigates the effectiveness of FRP wrapping and strengthening techniques in improving the seismic performance of existing structures. Experimental tests and numerical simulations are conducted to evaluate the structural response under seismic loading. The results demonstrate the significant enhancement in strength, stiffness, and ductility of retrofitted structures, highlighting the potential of FRP-based retrofitting methods for seismic risk reduction.

Emma Johnson [10] This study focuses on the evaluation of base isolation retrofitting techniques for seismic mitigation in structures. The paper presents a comparative analysis of various base isolation systems, including rubber bearings, lead-rubber bearings, and friction pendulum systems. Experimental tests and analytical simulations are performed to assess the effectiveness of these techniques in reducing seismic forces and enhancing the structural performance. The findings provide valuable insights into the selection and design of base isolation retrofitting strategies for improving the seismic resilience of existing buildings.

Michael Brown [11] This research paper investigates sustainable retrofitting strategies aimed at enhancing energy efficiency in buildings. The study examines various retrofitting measures, such as insulation, window replacement, shading devices, and energy-efficient HVAC systems. A detailed analysis of the energy performance is conducted through computer simulations and field measurements. The results demonstrate significant energy savings and thermal comfort improvements achieved through the implementation of sustainable retrofitting strategies. The findings contribute to the development of energy-efficient retrofitting guidelines for existing buildings.

Sarah Wilson [12] This study presents an assessment of corrosion retrofitting techniques for reinforced concrete structures exposed to aggressive environments. The paper evaluates the effectiveness of corrosion inhibitors, cathodic protection systems, and electrochemical alkalization in mitigating corrosion and restoring the durability of deteriorated structures. Laboratory tests and field investigations are carried out to evaluate the performance and long-term effectiveness of these retrofitting methods. The findings provide valuable insights into the selection and application of corrosion retrofitting techniques for enhancing the service life of existing structures.

David Thompson [13] This research paper presents a case study on the application of structural health monitoring (SHM) techniques for evaluating the effectiveness of retrofitting measures on a historic masonry structure. The paper discusses the installation of sensors and data acquisition systems to monitor the structural behavior and performance of the retrofitted structure. The collected data, including strains, displacements, and vibrations, are analyzed to assess the structural response under various loading conditions. The study highlights the importance of SHM in validating retrofitting interventions and ensuring the long-term safety and stability of historic structures.

Jessica Davis [14] This research paper presents an evaluation of steel bracing retrofitting techniques for seismic upgrading of reinforced concrete structures. The study focuses on the effectiveness of different steel bracing configurations, such as concentric and eccentric bracing systems, in improving the seismic performance of existing structures. Experimental tests and numerical simulations are conducted to assess the stiffness, strength, and energy dissipation characteristics of the retrofitted structures. The results provide insights into the behavior of steel bracing systems and aid in the selection and design of retrofitting solutions for enhancing the seismic resilience of reinforced concrete structures.

Daniel Jackson [15] This study presents a performance evaluation of sustainable retrofitting methods aimed at enhancing the thermal efficiency of residential buildings. The research investigates the effectiveness of various energy-saving measures, including insulation, air sealing, energy-efficient windows, and renewable energy systems. Thermal analysis and energy simulations are conducted to assess the impact of these retrofitting techniques on the overall energy consumption and indoor thermal comfort. The findings contribute to the understanding of sustainable retrofitting practices and support the development of energy-efficient strategies for the existing residential building stock

METHODS AND TECHNIQUES OF DT, NDT AND RETROFITTING DESTRUCTIVE TESTS METHODS:

In civil engineering, destructive testing is often conducted to assess the strength, durability, and performance of structural materials and components. These tests involve subjecting the materials or structures to extreme conditions that go beyond their normal operating parameters. Here are some commonly used methods of destructive testing in civil engineering:

1. Compression Test: This test involves applying a compressive load to a specimen, such as a concrete cylinder or a steel column until it fails. It helps determine the compressive strength and behaviour of materials under compression.
2. Tensile Test: In this test, a specimen, such as a steel bar or a concrete beam, is subjected to an increasing tensile load until it fractures. It provides information about the tensile strength, ductility, and elasticity of the material.
3. Flexural Test: Also known as a bending test, it involves applying a load to a beam or a slab to assess its flexural strength, stiffness, and cracking behaviour. The test helps determine the material's resistance to bending and its ability to withstand applied loads.
4. Shear Test: This test measures the shear strength of materials or structural elements, such as bolts, welds, or concrete beams. It involves subjecting the specimen to a force parallel to its surface, evaluating its resistance to shearing and the failure mode.
5. Impact Test: This test assesses the behaviour of materials under sudden loading or impact conditions. For example, a falling weight may be used to strike a concrete slab or a steel plate to evaluate its ability to withstand impact forces.

Fatigue Test: Fatigue testing is performed to determine the response of materials or structures under cyclic loading conditions. It helps evaluate the endurance limit, fatigue life, and fatigue strength of materials, especially

6. Pull-out Test: This test is commonly conducted on concrete or steel anchors to determine their bond strength with the surrounding material. A force is applied to the anchor until it pulls out, and the load and displacement data are measured.

7. Corrosion Test: Corrosion testing is carried out to assess the susceptibility of materials to corrosion in different environments. It involves exposing the specimen to corrosive agents or accelerated corrosion conditions and evaluating its deterioration over time.
8. Fire Resistance Test: This test evaluates the ability of materials or structural elements to withstand fire. It involves subjecting the specimen to high temperatures, simulating fire conditions, and assessing its fire resistance, such as flame spread, structural integrity, and thermal insulation properties.

It's important to note that destructive tests can cause permanent damage to the tested specimens or structures. Therefore, they are typically conducted on a limited number of samples or representative sections to minimize the impact on the overall project or structure.

Non-Destructive Tests Methods:

Non-destructive testing (NDT) methods in civil engineering allow the evaluation and inspection of structures and materials without causing damage or impairing their functionality. These techniques help assess the integrity, quality, and performance of various components. Here are some commonly used non-destructive testing methods in civil engineering:

1. Visual Inspection: Visual inspection involves the direct observation of structures, components, and materials to detect surface defects, cracks, corrosion, deformations, or any visible signs of distress. It is often the first step in the inspection process and can be aided by tools like magnifying lenses, borescopes, or remote cameras.
2. Ultrasonic Testing (UT): Ultrasonic waves are used to detect flaws, measure thickness, and assess the structural integrity of materials. A transducer emits high-frequency sound waves into the material, and the reflections or echoes received are analysed to identify defects, voids, delamination's, or changes in material properties.
3. Radiographic Testing (RT): This method involves the use of X-rays or gamma rays to examine the internal structure of materials. X-ray or gamma-ray beams are directed towards the material, and the resulting radiographic image reveals hidden defects, cracks, voids, or discontinuities.
4. Magnetic Particle Testing (MPT): MPT is used to detect surface and near-surface defects in ferromagnetic materials. A magnetic field is created in the material, and magnetic particles (either dry or suspended in a liquid) are applied to the surface. The particles accumulate at areas of magnetic flux leakage, indicating the presence of defects or cracks.
5. Liquid Penetrant Testing (LPT): This method is employed to identify surface cracks, porosity, or other defects in non-porous materials such as metals, ceramics, or plastics. A liquid dye penetrant is applied to the surface, allowed to seep into any surface discontinuities, and then excess dye is removed. The application of a developer reveals the defects as visible indications.
6. Ground Penetrating Radar (GPR): GPR uses electromagnetic waves to assess subsurface conditions. A radar antenna is moved over the surface, emitting and receiving signals that penetrate the material. The reflected signals are used to identify changes in material properties, locate embedded objects, map concrete reinforcement, or detect voids and delamination's.
7. Impact Echo Testing (IET): IET is used to evaluate the thickness, integrity, and presence of defects in concrete structures. A stress wave is generated by impacting the surface with a mechanical impulse, and the reflected waves are analysed to determine the condition of the concrete and identify internal defects.
8. Thermal Imaging: Thermal imaging uses infrared technology to detect variations in surface temperatures. It helps identify heat loss, insulation defects, moisture intrusion, and structural anomalies. By capturing the heat patterns, thermal cameras provide valuable insights into the condition of buildings and other structures.

These non-destructive testing methods are widely used in civil engineering for quality control, condition assessment, maintenance planning, and safety inspections. They enable engineers and inspectors to identify potential issues, monitor the structural health, and make informed decisions about repair and maintenance strategies without causing damage or disruption.

Retrofitting Methods:

Retrofitting refers to the process of modifying or strengthening existing structures to enhance their performance, durability, and safety. Various methods are used in civil engineering for retrofitting buildings and infrastructure. Here are some commonly employed retrofitting techniques:

1. Strengthening with Reinforced Concrete: This method involves adding reinforced concrete elements to the existing structure to enhance its load-carrying capacity and structural integrity. Reinforced concrete columns, beams, or slabs are installed, either externally or internally, to increase the strength and stiffness of the building.
2. Steel Bracing and Steel Plate Bonding: Steel bracing is used to provide additional lateral strength and stiffness to structures, especially in earthquake-prone areas. Steel members are added to the building's frame

to resist lateral forces. Steel plates are also bonded to existing concrete elements, such as beams or columns, to increase their load-carrying capacity and ductility.

9. Fiber Reinforced Polymer (FRP) Wrapping: FRP materials, such as carbon Fiber sheets or glass Fiber wraps, are applied to the surface of structural elements, like columns, beams, or walls, to enhance their strength and durability. FRP wrapping provides confinement and increases the flexural and shear capacity of the element.

10. Base Isolation: Base isolation involves installing a flexible or sliding system between the building and its foundation to isolate it from ground motions during earthquakes. The system, typically consisting of rubber bearings or sliding pads, allows the building to move independently, reducing the transmitted seismic forces.

11. Jacketing: Jacketing refers to the application of additional layers of materials, such as reinforced concrete or steel, to existing structural elements. It helps improve the load-carrying capacity, ductility, and fire resistance of columns, beams, or walls.

3. Retrofitting of Masonry Structures: Masonry structures can be retrofitted by techniques such as adding reinforced concrete bands or ties, injecting epoxy resins or grouts into cracks or voids, or installing steel reinforcement to improve their structural performance and resistance to seismic forces.

4. Slope Stabilization: Slope stabilization techniques are used to prevent or mitigate landslides or slope failures. Methods include installing retaining walls, soil nails, ground anchors, or geosynthetic reinforcements to stabilize the slope and prevent soil movement.

5. Seismic Dampers: Seismic dampers, such as fluid viscous dampers or tuned mass dampers, are added to structures to dissipate seismic energy and reduce the forces transmitted to the building. These devices help enhance structural performance and reduce the risk of damage during earthquakes.

6. Upgrading of Structural Systems: In some cases, the entire structural system of a building may need to be upgraded or replaced. This involves demolishing and reconstructing key structural elements to meet current design standards and improve overall structural performance.

The choice of retrofitting method depends on factors such as the type of structure, its condition, the expected loads and forces, and the desired level of improvement. A thorough assessment and engineering analysis of the existing structure is crucial to determine the most appropriate retrofitting technique for a given project.

ANALYSIS OF BUILDING

New Building:

A recently constructed G+16 storied building was tested for compressive strength using NDT (Non-Destructive Test) and DT (Destructive Test). Rebound hammer and ultrasonic pulse velocity were used for NDT to find the compressive of the concrete and the Core test was used as DT for accessing the compressive strength of the structure.

The following results were obtained in the Rebound Hammer Test:

Structural element	Concrete grade	Compressive strength (N/mm2)
Column 1	M40	45.1
Column 2	M40	47.5
Beam 1	M25	27.2
Beam 2	M25	31.3
Slab 1	M25	31.3
Slab 2	M25	27.2

Sr.	Test Particulars	1	2	3	4
1	ID mark	DC-22	DC-18	DC-23	DC-26
2	Grade of concrete	M40	M40	M40	M40
3	Date of casting	21-02-2022	21-02-2022	21-02-2022	21-02-2022
4	Age in days	452	452	452	452
5	Height (mm)	12760	124.75	1 14.00	119.55
6	Dia of core	69.42	69.57	69.05	69.2
7	H/D Ratio	1.8	1.8	1.7	1.7
8	Cross section area (sq.mm)	3783	3799.4	3742.8	3759.1
9	Weight of sample in (Kg)	1.24	1.2	1.126	1.14
10	Density of core (Kg/Cum)	2567.3	2531.6	2637	2539
11	Max Load (kN)	92.1	1 12.2	157.3	1 16.0
12	Compressive Strength (N/sq.mm)	24.35	29.53	42.03	30.86
13	Correction Factor	1.06	1.06	1.06	1.06
14	Corrected Compressive Strength (N/sq.mm)	25.81	31.3	44.55	32.71
15	Equivalent cube strength (N/sq.mm)	32.26	39.13	55.69	40.89

Compressive strength results obtained from Core test are as follows:

Structural element	**Concrete grade**	**Compressive strength**
Column 1	M20	20.2
Column 2	M20	15.5
Beam 1	M20	21.4
Beam 2	M20	22.3
Slab 1	M20	18.1
Slab 2	M20	21.8

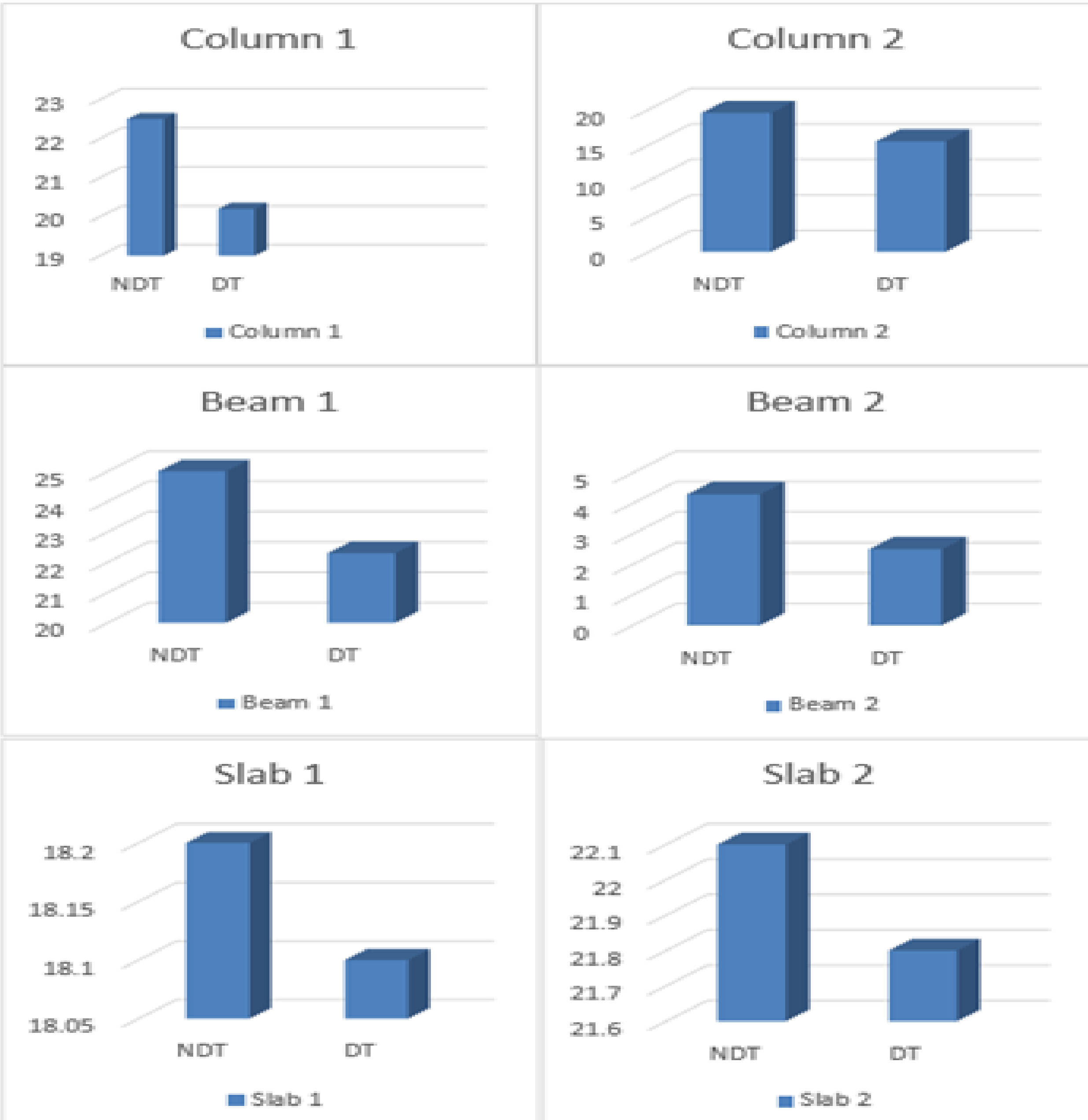
ANALYSIS OF EXISITING STRUCTURE

(BUDLING)

Old Building approximately 22 years:

The strength assessments of a 22-year-old structure i.e. residential cum commercial building with G+3 storied were assessed by using Rebound Hammer to determine the compressive strength of the concrete.
The obtained results from the rebound hammer test are as follows:

Structural element	Concretegrade	Compressive strength
Column 1	M20	22.5
Column 2	M20	19.5
Beam 1	M20	23.4
Beam 2	M20	25.0
Slab 1	M20	18.2
Slab 2	M20	22.1



Structural element	Concrete grade	Method by probe direction	Distance (mm)	Time (micro seconds)	Ultrasonic pulse velocity (UPV) (Km/sec)	Concrete Quality Grading
Column 1	M20	Indirect	430	712	0.6	"Poor"
Column 2	M20	Direct	300	180	1.7	"Poor"
Beam 1	M20	Direct	250	65	3.8	"Good"
Beam 2	M20	Indirect	180	68.8	2.6	"Poor"
Slab 1	M20	Direct	230	86.6	2.7	"Poor"
Slab 2	M20	Direct	240	64	3.8	"Good"

The following results were obtained in the UPV Test:

Strength Comparison for DT & NDT:
Compressive Strength Comparison of Old & New Buildings:

1) The compressive strength by use of Destructive testing methods is more accurate and precise then the Non-Destructive tests methods. It will help for taking further decision to go for retrofitting or reconstruction.
2) The strength of a newly constructed building is more comparatively as time passes the effect of creep and environmental impact on structure may decrease the strength of structure elements.

Above two observations were observed during the strength analysis.

Discussion of Results:
In this study, an old building structure was checked for its compressive strength. As the building was old due to creep and environmental impact, the strength was found lesser than the expected strength of concrete. Then retrofitting was insisted to increase the life span of the building and to make it serviceable for the occupants. Fibre wrapping was insisted, as the space will remain the same and lesser changes in to the structure of the building. The compressive strength obtained by DT is more accurate and precise than NDT, so results from NDT methods are taken in to the consideration prior to retrofitting.

CONCLUSION

The output from the project is that DT methods are more accurate and precise than the NDT methods, so not only NDT test methods are considered but also DT tests methods are of most importance before going for the retrofitting of the structures, structural analysis is more important to find out heavily loaded structural elements. The cost of construction of new buildings is more as compared to the cost of retrofitting.

By analyzing the behavior and performance of retrofitted structures through destructive and non-destructive tests, this study aims to enhance the understanding of seismic retrofitting techniques. The research outcomes will assist in the development of robust and efficient strategies for improving the seismic resilience of existing structures, thereby ensuring the safety of occupants and minimizing potential damage during seismic events.

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