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ANALYSIS OF REPAIR AND REHABILITATION TECHNIQUES USED IN GOVERNMENT MEDICAL COLLEGE AND HOSPITAL (OLD BUILDING), RAJOURI

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ABSTRACT

In the past one hundred years, reinforced cement concrete has been used extensively in India and all over the world. Its use has seen has tremendous incline especially in past 40 to 50 years. Humans have progressed by leaps and bounds in these years and with this progress, they have created huge number of infrastructural assets which are a proof of his intellect and his architectural and engineering ability. He has created high rise buildings, bridges, dams, tunnels, sports stadiums, and mighty residential buildings etc. which are an essential part of modern civilization. He has invested hugely in terms of resources in the construction of these structural assets. These structures are made after a lot of capital investment and time and hence they are not something which can be constructed again and again. We simply don't have enough resources and time that we keep on constructing a structure time and again. So, it is very important that these structures serve their purpose for the period of time they are made to remain intact and working. Hence, it has to be ensured that they keep in good condition and keep performing well and even if they don't main their intactness completely, they should be brought back to their original condition by spending minimum amount of time and resources. The main aim of this research is to obtain empirical data of this full scale building and then to investigate the long and short term performance of most widely used repair and rehabilitation methods. The benefit of this study is that it will establish a basis for more efficient designs of the structures as per the requirements. This will also extend the repair interval between two needed renovation processes. It will also reduce the frequency of monitoring the structure and also intend to find some alternate repair and monitoring strategies as per the given area. The need for repairing and rehabilitation of structures is increasing with every passing day in Jammu and Kashmir, all over India and throughout the world. The areas which are hit by disasters such as earthquakes, floods and other natural or manmade disasters in particular require rehabilitation of structures and reconstruction has to be done in order for the people to remain safe and sound.

KEYWORDS: Repair, renovation, rehabilitation, RC structures, Non Destructible tests, shotcrete, ferro-cementing.

INTRODUCTION

Renovation of a building is done after emptying the building from its inhabitants and all other useful materials that are present inside the building. Renovating building does not only mean increasing its strength and power by making reductions and alterations in the balance of the structure rather it means an overall change in terms of every design aspect so that there is a perfect balance between resilience, power, aesthetic appeal, reinforced materials and seismic repetition. And in order to achieve these projects, changes in every aspect of the building is done like building additional walls, fitting new reinforcements, stainless steel, strengthening existing walls, providing necessary partitions etc. Installation of RC shear walls can prove very handy, as we have seen in various cases that it has been able to counter and resist, to a certain degree effects like continuous and unchecked erosions, backlogs and the damage that otherwise would have been caused to structural elements undergoing sustained deterioration. Reinforced concrete bars used make sure that they now provide extra support to the already present steel bars that are now lacking strength required. They are one of the most important and frequently used item in any rehabilitation process and when used in combination with RC frame ports, they provide support to the existing structures. Using a combination of new reinforcements with providing the infill wall means that the structure can now be increased in length as well as height provided the balance and load distribution is taken care of. That means the structure can now be increased from 2 to 3 existing floors to up to 5 floors. And in the similar way, the building can be increased laterally and the side strength or lateral strength of the structure can thus be increased by providing the walls on the wings also called as side walls or buttress walls. Although less practised because of the spacing issues but if there is ample space, this method can be used. Similarly, the structure can be reduced in volume and size if the newly required building needs to be smaller in size by removing side walls a to reduce the lateral size of the building and by removing floors from top to bottom approach so as to reduce the building in vertical dimensions. Similarly, some unwanted walls from the middle of the structure can also be removed and thus space for usefulness can be free accordingly. The foundations can also be altered in the same way. If the loading is to be increased we will want more support to the existing foundation but in case the load is to be reduced we don't remove anything from the base as it is too complex and too risky a process to alter the footings. The building having cracks in the walls and in other places of the structure, as it is seen in most of the older structures, the same can be treated by applying resins. A resin is a mixture of usually different materials such as epoxy, polyester and other catalysts reacting chemically that are used to repair any cracking in walls and are also used to treat damaged concrete. They are relatively cheaper materials and because of having different constituent materials with different compressive strengths and different temperature coefficients, they are now very less used and have been replaced by new methods, one of which is shotcrete. However they have some good qualities such as resistance to acid and sulphate attacks, high tensile strengths, excellent bonding with masonry and concrete. Shotcrete is a relatively newer method of repairing walls and any crevices in the structure it is done by applying concrete usually through a hose under pressure. Shotcrete provide excellent bond strength with existing concrete and it is quite efficient in filling up the voids however two basic problems with it are over spraying and rebounding which make this process less efficient and costly. It also requires specific equipment and skilled person to do the procedure which results in this process being employed in only major projects and makes it unavailable for less important and projects where costs are the major concern

OBJECTIVES

Following are the main objectives that are supposed to get completed during this whole project:

1. To have an insight of various repair and rehabilitation techniques that are used currently all over India
2. To review the existing latest techniques that were used in this project to stop the deterioration process and do the rehabilitation keeping in mind the nature of this project, the area in which this project is to be completed, availability of material resources and both skilled as well as unskilled labour.
3. To obtain the data and results before and after the repair process and assess the performance of the techniques used in the rehabilitation process by comparing both the results.
4. Considering the nature of the project, that it was a hospital building in a far-flung area which needs to be completed as soon as possible, check from the results whether all the repair processes were safely conducted and the project was completed well within the timeframe and within the projected cost so that it remain benchmark for similar future projects.
5. To examine the performance of various sections and from the results obtained, it is to be examined whether this project can become a point of reference for other similar projects in future by checking the end strength of all the renovated members achieved after the rehabilitation process by performing suitable in situ and NDE tests.
6. To have a review of the rehabilitation processes and under the idea of green construction, examine how safer, sustainable and environment friendly were the set of methods, practices and equipment that were employed.

LITERATURE REVIEW

CPWD Handbook on Repairs and rehabilitation of RC Buildings, New Delhi, 2002. In this handbook, CPWD has concluded in its studies that while buildings and other reinforced cement concrete structures have generally a certain period of useful life that depends upon various circumstances, most importantly the specifications adopted.

Balamuralikrishnan R and Thirugnanasambandam S, 2016. Paper titled as “Repair and Rehabilitation of structures” and published in IJAR. The study concluded in this paper mainly focusing on different aspects of repair technology and selection of materials based on their properties, their dimensional stability, in situ compressive strength, porosity, permeability, modulus of elasticity, resistance against chemical attack. Adhesive as well as cohesive properties, thermal expansion coefficient, etc. This study mainly focuses on various repair technology aspects with different materials and their testing.

Suresh Kumar S, Mukesh, Rishabalaxmi M, Prithiviraj K, 2019. Published titled as “An experimental study of repair and rehabilitation of structures” in IJSER journal. The authors in this paper present an experimental study of Repair and Rehabilitation of old Heritage Buildings. In present processes of Building Research, the process of Repair and Rehabilitation plays an important role in building applications. It acts as an inevitable solution for maintaining the health and quality of Structures. Repair and Rehabilitation of old heritage buildings which have been constructed with greater care, love and devotion has become a cause of concern all over the world, even in many renowned and economically and technologically advanced countries.

Hemant P Singh and Raju Ranjan Yadav, 2020. In this paper various techniques of repair and rehabilitation of

reinforced cement concrete structures are discussed by the authors. The authors acknowledge that in certain cases, during the construction process many requirements are not met which results in faulty designs and therefore premature decay of the structures do take place and therefore, the structures need to be repaired. For repairing concrete, they have used the methods of jacketing of beams, columns and increasing slab thickness and also rehabilitation of cover material and loose concrete. Steel has to be either replaced or fibre wrapped. Footings have to be extended and in certain cases, if possible to do, made deeper.

George Alfredo Anguilar, 2000. In this paper, the authors carry out the case study of repair and rehabilitation of existing RCC buildings after the 1995 massive earthquake in Mexico City which resulted in huge amount of destruction of property and lives. There was a common pattern in which destruction occurred and the authors pointed it out in the paper. The results from the study were widely appreciated and many results were taken out that helped in the rehabilitation process afterwards.

Pardhaan L and Kondreivandhan Setu, 2009. Their work primarily focuses on to the result of the closure of Ferro-cement in concrete conduct. The effect of the different levels of reinforced concrete combined with Ferro cement was studied in detail. They kept all the other parameters constant without defining the initial process during their course of the investigation throughout the course of action. The concrete mix design of M25, M30, M35, M40, M45, M50 and M55 have a compressive strength of respectively as 25, 30, 35, 40, 45, 50 and 55 [N / mm²]. They distributed 42 cylindrical and hemispherical specimens (21 each controlled and confined samples) with a diameter of 15cm and a height of 90 cm, which are three models each for different grade of concrete.

Badaux M and Jisra, (2006) Their work titled as Retrofitting of RCC structures with steel bracing system at preceding of TABSE symposium, University of Texas have provided a thorough insight of how to work on RCC buildings having defects in columns and beams. They have illustrated thoroughly as how to successfully work on the beams and columns that have over the span of time been put under lots of loads and thus have clear signs of fatigue and shear. Steel bracing is a very effective way of securing columns that have been used in different parts of the world in both medium and small sized structures.

Meli R. ET. al. (2003) Evaluation of performance of concrete buildings damaged by September 1995 Mexico earthquake performed informal testing of the RC structure using a pre tensioning and post-reconstruction method. The main difference that in the power parameters of the structure and the pushover curve was specified for the ductility extension method. As far as the consistency of the structure is concerned, it was seen that it remained same until the flux point in the line, while the section that was not-linear, the size of each point increased and as a result the transformation after re-enlargement, other noticeable changes too took place orderly.

METHODOLOGY

Rehabilitation measures used in reinforced concrete building of the hospital:

The decision to repair the structure is taken only after thorough examination of the structure and keeping in mind the likely service life of the structure that has to be based on both economical as well as technical aspects. A strategy is devised based on available resources keeping in mind the main objective. Priority should be given to the fact that the structure having most damage is to be treated first and no further damage should occur to the structure.

Using Shotcrete

Shotcrete is one of the most effective and economically viable technique of concrete repair. Concrete is a fantastic

building material but as it is with most of the things, it also loses its strength over time and develops cracks and fissures. In shotcrete, concrete is pneumatically sprayed at a very high speed through a pipe in to the receiving area. It is best suited in vertical and overhead repairs where normal repair measures harder to perform. This method can be used in any form of repair such as in columns, walls, piers, vertical as well as horizontal surfaces, ceilings, slabs, overhead decks etc. most important thing in repair process is that it should be easy, economical, hassle free and less time consuming, which is the exact case with this method. In this building, various concrete blocks were repaired using shotcrete method. Some of them are illustrated below.



Figure 1 Application of shotcrete

RCC Jacketing

Concrete jacketing increases the size of the treated member significantly both lengthwise as well as breadthwise. The member as a result becomes stronger under deformation or buckling. The stiffness of the member increases and so deformations are now under control. This method is employed in two main cases. First is when the old concrete structure has reached the limiting value of strain and no more strain can be allowed. Second is when the old RC structure become porous and has weathered a lot over the span of times. It is oldest and in some terms cheaper method of repairing the older structures. The illustration of the use of this method in the hospital building is shown through two figures.



Figure 2 Concrete jacketing of columns and beams

Polymer Concrete System

Polymer concrete is the type of concrete in which we use polymers to replace cements as a binder. When polymers are added up in addition to Portland cement, the resultant is called as Polymer Cement Concrete (PCC) or Polymer Modified Concrete (PMC). An American Committee 548 of the American Concrete Institute oversees all the developments done in the field of polymer concrete since it was formed in 1971. A new method used these days is the use of polymer concrete system. However, this method is very expensive one and is used in only high end buildings. Two main monomers used in this system are Methyl Methacrylate (MMA) and Vinyl resin, both of which together form excellent bonding material. This composition is also used at times to repair damaged structures. They are also used for patching, overlays, filling up crevices, in gates, in flooring and roofing and other structural members.



Figure 3 Polymer concrete cubes and its use in column fills.

Why do we need to use polymer concrete?

The polymer concrete is better than the ordinary concrete because it has following properties:

1. High impermeability: Polymer concrete has very less permeability as compared to the OPC concrete due to which there are very less cracks and porosity is also reduced greatly.
2. High durability: The polymer concrete is denser and water tight concrete when compared with OPC. This prevents it from chemical attacks, water penetration and therefore reduces the chances of corrosion. The small internal micro cracks in the body of cement matrix are also prevented. This increases the overall stability and lifespan of the structure.
3. Resistant to weathering action: Due to its overall better performance than the OPC concrete, the polymer concrete is better performing against chemical attacks.

Main uses of Polymer Concrete System:

- Covering bridge decks
- Constructing floors
- Precast construction
- Used for patching works

Steel Jacketing

Steel jacketing is a method of structural rehabilitation process that is used for strengthening and supporting a building. It is used to enhance the load bearing ability of a structure and also to restore back the design integrity of a structural member. This method of rehabilitation is predominantly used on vertical structural members such as walls, columns and side beams. In this method reinforcement is provided both longitudinally as well transversally in a structural member with added concrete. A cage of steel reinforcement or a casing is generally made around an existing column to strengthen it and restore it the original condition and strength. By using this method concrete, steel and timber sections can be prevented from further deterioration.



Figure 4 Steel jacketing in beams and columns

Ferro-Cementing

Ferrocement is a building material consisting of wire mesh and cement mortar. The use of ferro-cement in construction is diverse due to its low weight, lack of skilled workers, and lack of framework and so on. Created by P.L. in 1940. Developed by Italian architect Nervi. Components are manufactured with less machine setup and on-site execution time, ensuring the quality of ferro-cement work. Maintenance cost is low. This material has been widely used in construction only in the last 20 years. This method of building rehabilitation is used to provide a protective strong reinforced membrane to a fatigued RCC structure. This is a method of using reinforced mortar which is applied over a metal mesh which is joined together by wires having diameter ranging from 12-30 mm. It is a thin wall like structures with spacing of 4 to 6 mm which is connected to the original main wall using screws or bolts. This structure has excellent resistance to corrosion, it is absolutely impermeable to water and is distributed uniformly to avoid shrinkage cracks.

Properties of ferro-cement:

- Versatile form of cement concrete that can be used for repairs.
- A type of reinforced concrete construction which is relatively thinner and in which many small diameter wire meshes are distributed uniformly throughout the cross section.
- Mesh can be of metal or any other suitable material.
- Instead of ordinary concrete, Portland cement mortar used.

- Strength depends on two factors; one is the quality of sand and cement mortar and other is quantity of steel mesh used. Main materials used in ferro-cementing:
- Fine aggregates
- Admixtures
- Cement
- Reinforcing mesh
- Skeletal steel

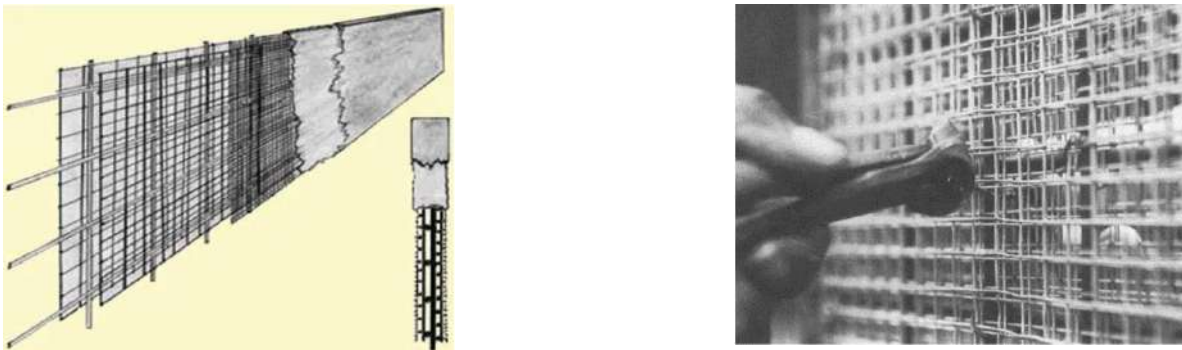


Figure 5 Cross section and reinforcing mesh used in ferro-cementing

Plate Bonding

Also called as bonded steel plate reinforcement. This is an inexpensive method of reinforcement in which a highly adhesive structural material is used to connect the steel plates to the surface of the parent surface so as to improve the load bearing capacity of the structure. This method finds its origin in South Africa in the late 1960s. It is a very fast method and requires 2-3 days to be completed and gives very good results. The new plate installed has usually higher tensile strength and hence it when used with concrete forms an excellent structural member. The steel consumed is also low in this method when compared with other methods. The composite steel sheet reinforcement method is a type of reinforcement method that uses a high-strength building adhesive to bond a steel sheet to the surface of a structural member to improve the structural strength of the structural member. This process began in 1967. South African scholars Fleming and King conducted experiments to reinforce concrete beams by gluing steel plates on the outside instead of steel bars. In the experiment, a steel plate was glued to the lower tension side of the concrete beam to demonstrate the feasibility of this strengthening method. Over the next decade, domestic and foreign scientists have conducted a number of experimental studies, theoretical analyses and engineering training. Adhesive steel sheet reinforcement methods have gradually matured and are widely used in concrete bending reinforcement projects, eccentric compression and tension member



Figure 6 Plate bonding in structures

SCOPE OF APPLICATION OF PLATE STEEL SHEET REINFORCEMENT:

Due to the principle and stress characteristics of concrete parts reinforced with composite steel sheet, this reinforcement method has a wide scope of application:

- Reinforced concrete Suitable for bending, eccentric compression or reinforcement of tension members, but not for simple concrete parts including those with a reinforcement ratio of less than 0.2% on one side of the vertical reinforcement.
- Since the steel plate is glued to the concrete surface, the concrete strength of the reinforcing component is very important for the entire reinforcement system. Therefore, in general, the measured concrete strength of the stiffener should not be less than C15 and the bond strength between the steel plate and the concrete should not be less than 1.5 N / mm².
- Since the adhesive of the steel sheet reinforcement system is soft, the performance of the adhesive will be significantly reduced if the glass transition temperature is exceeded, so the use of the adhesive is a supplier. Currently, the glass transition temperature of structural adhesives in commercial buildings is approximately 6082 ° C.
- Considering that the temperature of a typical concrete structure is less than 60 ° C, the ambient temperature should be less than 60 ° C for long-term use of steel sheet reinforced concrete structure. Higher than 60 ° C. Not only do we take appropriate protective measures in accordance with relevant national standards to strengthen concrete structures in special environments (hot and humid, moderate corrosion and radiation, etc.), but also environmentally resistant construction adhesives. To special technical requirements that must be used and glued accordingly.

Steps involved in plate bonding process:

- Sticky Veneer process which involves cleaning the surfaces and polishing the surfaces so as to make it ready for dressing.
- Punching bolt holes.
- Preparing adhesive, which is a homogenous mixture of two or more liquids mixed until them forming appropriate thickness and uniform colour.
- Pasting the glue after the adhesives are prepared, coated on the treated steel plate surface with the help of greasy knife. Glue section should be triangular with middle thickness about 3 mm, and the edge thickness of 1 mm. Steel plate is then pasted on the concrete surface, fixed with a fixed compression system, and thereafter pressurized to ooze out any remaining glue.

- Testing and appropriate maintenance

TESTS PERFORMED

There are a number of non-destructive evaluation (NDE) tests which can be performed so as to find out various parameters of different members of a structure. Samples are taken from the required member such as a beam, column, slab etc. and is tested thereafter so as to check whether the desired results have been achieved or not. To check the in-situ strength of the concrete members following tests were performed. There have been explained one by one below.

- 1. Rebound hammer test:** Rebound Hammer test is a type of Non-destructive testing method of concrete which gives a convenient and quick indication about the compressive strength of a particular sample of concrete. It is also called as Schmidt hammer and it consists of a spring controlled mass which slides on a plunger encased with a tubular housing. When the plunger of the Schmidt hammer presses on the surface of the concrete sample, a spring controlled mass which has constant energy is then allowed to hit concrete surface and is mad to rebound back. The extent of the rebound of the hammer, which is the measure of hardness of surface, is measured then on a graduated scale attached. This measured value is called as the Rebound Number or rebound index. A concrete sample which has low strength and low stiffness absorbs more energy and will eventually have lower rebound value.

Objectives of Rebound Hammer Test:

- To determine the compressive strength of concrete
- To determine the uniformity of concrete
- To know the quality of concrete as per required specifications
- To compare two concrete samples

S. No.	Average rebound number	Quality of concrete
1	>40	Very good hard layer
2	30-40	Good layer
3	20-30	Fair
4	<20	Poor concrete
5	0	Delaminated

Tablshowing quality of concrete for different values of Rebound number.



Figure 7 Rebound hammer test being performed on a column.

1. **Ultrasonic Pulse Velocity Test:** This test is also known as UPV test and it is a recognised type of in-situ and non-destructive evaluation test (NDE) used to qualitatively determine the homogeneity and integrity of the concrete sample. This test is done by passing a pulse of ultrasonic wave through the concrete sample to be tested and the time taken by pulse to get through the structure is measured. If velocities are higher, it indicate good quality and continuity of the concrete, while low velocities indicate that concrete has cracks or voids. This test is used to access:

- Strength of concrete and its gradation in different places of structural members.
- Any sort of discontinuity in the cross section of the concrete such as cracks, concrete cover delamination.
- Depth of cracks on the surface.

- Determine the dynamic modulus of elasticity of concrete.



Figure 8 UPV test being conducted on a sample of concrete taken from a beam.

S. No.	Pulse velocity (km/s)	Concrete quality
1	>4.0	Very good to excellent
2	3.5-4.0	Good to very good, slightly porous
3	3.0-3.5	Satisfactory but loss of integrity suspected
4	<3.0	Poor and loss of integrity exist

showing guidelines for concrete quality based on UPV test

2. **Windsor Probe or Penetration resistance tester (PNR):** ‘Windsor Probe’, as it is widely known, is at certain type of penetration resistance measurement device. It consists of a gun driver that is actuated by gunpowder, a hardened rod probe made of alloy, loaded cartridges, depth gauge and with it other related accessories. In this device, the gunpowder-actuated driver fires a hardened probe which is made up of alloy into the surface of the concrete. During testing process, the exposed length of probe is measured by a gauge which is already calibrated accordingly. The coefficient of variation is usually expressed in terms of the depth of penetration which gives the fundamental relation between concrete strength and related penetration depth.



Figure 9 Windsor probe device



Figure 10 Doing Windsor test

3. **Core cutting test:** This test is used to get the direct assessment of strength of concrete which is not the case with other tests. The other tests give kind of indirect details of concrete quality. The cores are cut from desired locations by using rotatory diamond pointed cutting tools which take out the sample in the form of small cylinders. The samples thus obtained have uneven ends which are then made even using suitable methods. The sample can give many details about the materials and quality of concrete used and the reinforcements and can be helpful in various other analysis such as;

- Determination of strength and density
- Determination of carbonation in concrete sample
- Chemical analysis of concrete
- Water or gas permeability
- Petro graphical analysis of concrete
- ASHTPO Chloride test for permeability



Figure 11 Concrete sample being taken using a core cutter tool

4. **Pull-out test:** This test is of further two types depending on the placement of the ring in the fresh concrete.
LOCK test: This test system is used to find out a reliable estimate of the strength of concrete which is newly casted in a building as per the pull-out test method. The result is achieved by measuring the force which required to pull out the steel ring which is embedded in the fresh concrete against a circular counter pressure which has been placed on the concrete surface.
CAPDO test: The difference in this test is that this method permits performing pull-out test on an existing structure without the need of putting preinstalled inserts in it.
5. **Carbonation test:** This test is performed to determine the thickness of concrete affected due to mixed attack of atmospheric carbon dioxide and moisture in air causing a decrease in level of alkalinity of concrete structure. A spray of 0.2% phenolphthalein solution is used as pH indicator of sample concrete. The change of colour to pink shows that the concrete is in good form and if no change in colour takes place, it means that concrete is carbonation-affected.
6. **Chloride test:** Chloride content can be found from broken samples or core samples of concrete to be tested. Mainly, the level of chloride near the interface of steel-concrete is of importance. Some of the chlorides present in concrete are fixed as well as some are free. Although the water soluble chloride ions which are of more importance when we talk of corrosion risk. The total content of acid soluble chlorides is found in accordance with IS: 14959 Part III (2001).

RESULTS

1. Rebound hammer test results:

S. No.	Members	No. of members	Eq. cube strength(N/sq.mm)	No. of readings taken
1	Columns	18	32	152
2	Beams	22	38	79
3	Slabs	14	45	88

Table 3 showing rebound hammer test results

2. Core Cutting Test results

S. No.	Test performed for	Average value
1	Equivalent compressive strength of concrete	139.45kg/sq. cm
2	Density of concrete	1950kg/cu.m

Table 4 showing core cutting test results

7. Ultrasonic Pulse Velocity test results:

Table 5 showing UPV test results

S. No.	Pulse velocity(km/h)	No. of readings	Quality of concrete
1	0.0-2.0	20 13 30	Poor
2	2.0-3.0	15 60 40	Doubtful
3	3.0-4.0	32 15 15	Medium
4	3.5-4.5	30 5 4	good

CONCLUSIONS

- This study highlighted the main failures that were caused to the structure of the Government Medical College and Hospital and also provided the remedial measures to tackle these problems. As it was discussed in the study that cost is the main deciding factor as to which building needs renovation and what techniques to be used for the rehabilitation process. For example, if there is no bar on cost, a complete shattered structure can be brought back to its original form with thinking of the cost issue but we know that is not the case, especially in a state like that of Jammu and Kashmir where infrastructure development has still a long way to go.
- Periodic maintenance of any structure is essential. Although enough measures should be taken during the time of planning and construction that the requirement of frequency of maintenance should as less as possible. However, maintenance is still a necessary part of any constructional project.
- Each and every problem should be properly analysed by a team of experts before applying any repair technique. Every technical aspect related to a particular method should be discussed before undertaking the actual repair work.
- It is to be noted that just because a technique has worked for a certain project it will work everywhere. Every project and problem is different with respect to different reasons and poses different challenges. So, every repair technique is helpful for a particular application for which it is meant.
- Cost is the deciding factor for any project but keeping in mind the safety and long run performance of the project, it should not be a significant planning factor and a window for compromises on cost should always be kept open.
- Despite of all the hurdles, the work was completed and now this work can be used a milestone for various other similar works of this kind in this area. Many techniques used in this study can be repeated in many other similar cases which is the main purpose of this study. That is to provide potential remedial measures. It is because of less awareness of people regarding the modern techniques that they usually prefer to use same traditional and indigenous techniques over and over again.
- This is true that various techniques in this study are too expensive to be carried out and used by people individually. However if finance is not an issue, techniques such use of polymer concrete, Ferro-concreting, composite jacketing and plate bonding are good enough to be used anywhere.

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