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The Study for Checking Of Quality of Construction in Buildings

Vikas Walia, Dr. Arvind Dewangan

Abstract— **Owners and designers may find themselves confronted with the task of deciding what to do with an existing masonry building, particularly if there will be a change of use or modifications to the structural system. Part of that decision should include determination of whether the structural system is adequate in its current condition for the building's intended use, whether minor or extensive repair and retrofit measures are required, or whether the building has deteriorated to a state that it is beyond its usable life. Nondestructive and minimally invasive diagnostic techniques play a vital role in determining properties of existing masonry construction without causing excessive disturbance or disruption to the building fabric. This article discusses the different methods available for identifying masonry distress conditions and evaluating engineering properties such as strength and stiffness.**

Key Words : Nondestructive Technic, Masonry Strength
Sub Area : Construction Technology & Management
Broad Area : Civil Engineering

I. INTRODUCTION

The masonry material properties needed by the engineer will ultimately depend on the role of masonry in the overall structural system, but may include compressive strength, shear strength, presence and extent of voids, existence and condition of reinforcing, and even moisture resistance. The use of destructive techniques may be undesirable due to the cost, damage and potential structural instability resulting from creating large openings or removal of several material samples. Fortunately, many nondestructive and in-situ methods exist, several of which have standardized procedures to determine necessary material properties without causing undue damage to the structure.

The keys to establishing a successful masonry testing program include determining which material properties are critical to the building's intended use, as well as selecting an appropriate number of tests and test locations. For reinforced masonry, quantifying the presence of voids in grout, and location of reinforcing are likely to be some of the most important properties. For unreinforced masonry, particularly in historic construction, determination of compressive strength, elastic modulus, and shear strength is especially important in order to take advantage of these inherent material properties in design.

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Vikas Walia, M.Tech.4th Semester student Civil Engineering (Construction Technology & Management Kaithal), HCTM Technical Campus Kaithal, India Haryana

Dr. Arvind Dewangan, Professor & HOD - Civil Engineering Department, HCTM Technical Campus Kaithal, Haryana

In situations where variable construction or workmanship are encountered or suspected, additional testing can also help determine appropriate design values for different construction phases or parts of the building. For nonstructural masonry such as veneers, the focus will more likely be on connections to the structural system, moisture management, and energy issues rather than strength properties. "Construction work" includes:

(a) building, including excavation, and the construction, alteration, renovation, repair, maintenance and demolition of all types of buildings or structures.

(b) civil engineering, including excavation, and the construction, structural alteration, repair, maintenance and demolition of for example, airports, docks, harbours, inland waterways, dams, river and avalanche and sea defence works, roads and highways, railways, bridges, tunnels, viaducts and works related to the provision of services such as communications, drainage, sewerage, water and energy supplies.

(c) the erection and dismantling of prefabricated buildings and structures as well as the manufacturing of prefabricated elements on the construction site.

"Employee" means an individual who works under a contract of employment or apprenticeship."Employer" means a corporation which, or an individual who, employs persons under contractsof employment or apprenticeship.

"Principal contractor" means the person with overall responsibility for the construction work and includes the owner builder. Depending on the contractual arrangements which are in place, the principal contractor may be an employer, self-employed person or a person in control within the terms of the Occupational Health and Safety Act.

"Self-employed person" means a person who works for gain or reward but not under a contractof employment or apprenticeship, whether or not they employ others.

"House" means:

(a) a building designed as a single dwelling on one block of land, or, in the case of dualoccupancy.

(b) a building(s) designed to include two dwellings (erected side by side or joined together to form a single building) on one block of land.

II. NON-DESTRUCTIVE TECHNIQUES

Voids and Reinforcing

When investigating how solidly an existing masonry wall was built, simply tapping with a sounding hammer may be sufficient to determine if CMU cells are grouted or empty. For smaller voids and cracks in thicker, multi-wythe walls, more sophisticated techniques and equipment may be needed. Ultrasonic methods, such as pulse velocity which measures the transit time of stress waves between transducers, or impact-echo which measures the stress wave reflections from discontinuities in the structure, are both good tools for assessing the extent of internal cracks and voids. These types of irregularities can also be observed visually through the use of a fiber optic borescope inserted into an existing opening or small diameter drilled hole within a mortar joint (Figures 1 and 2). This method is also useful in cavity wall construction for observing veneer ties or excess mortar inside the wall cavity. Somewhat larger scale voids can be detected through the use of Surface Penetrating Radar (SPR) which locates material differences indicated by reflected microwave energy, and Infrared Thermography (IRT) which is capable of detecting temperature differences between the solid masonry materials and voided air spaces.

After repairs, strengthening, or stabilization work have been completed, a long term structural monitoring program will result in valuable data that will aid in diagnosing future distress, aid in detecting potential problems before they become serious and more expensive to fix and, finally, ease concerns about long term structural performance.

Material characteristics	Test Method
Compressive strength/Elastic modulus	Flatjack (ASTM C1197)
In-situ stress	Flatjack (ASTM C1196)
Shear strength	Flatjack “shearjack” (ASTM C1531)
Voids	Surface penetrating radar, Infrared thermography, Borescope, Sounding, Pulse velocity
Cracks	Impact echo, Pulse velocity (ASTM C597)
Reinforcing and metal objects	Surface penetrating radar, Pachometer
Reinforced condition	Borescope, Ultrasonic thickness gauge, Half-cell potential (ASTM C876)
Mortar consistency & quality	Rebound hammer, Resistance drill
Moisture penetration	Spray chamber (ASTM C1601), IRI, Water tube (RILEM II.4)
Cracks width & building movement	Structural monitoring

Masonry Strength and Stiffness

An estimate of masonry compressive strength and elastic modulus is determined through the use of Flatjacks following the standard test method of ASTM C1197. Flatjacks are thin hydraulic bladders inserted into slots cut in masonry bed joints, and pressurized to perform an in-situ compressive strength test while monitoring the surface strain of the masonry between Flatjacks to generate a stress-strain curve (Figure 3). Although this method requires sawcutting two slots in the mortar joints to insert the Flatjacks, it is much less destructive than the removal of masonry prisms, which may be damaged during sampling or transport.

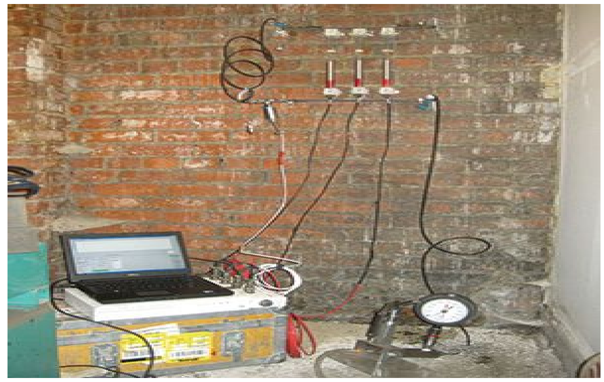

Figure A

Figure A: Masonry deformability test by the Flatjack method to estimate masonry compressive strength and elastic modulus. Both Flatjacks are pressurized while monitoring surface strain to generate an in-place stress-strain curve.

If the current stress state of the masonry is desired at a particular location, the single Flatjack method of ASTM C1196 provides a means to measure this property. First, the stress is relieved by cutting a horizontal slot in the bed joint, which also causes the masonry above to deform slightly. The Flatjack is then inserted and pressurized, and the pressure is measured as the masonry above is restored to its original position.

Similarly, masonry mortar joint shear strength may be measured using the standard test method of ASTM C1531, which utilizes a single specially sized Flatjack, also known as a "Shear jack," to fit within a head joint, which is pressurized until it moves the adjacent brick unit sideways into the opposite, previously opened head joint.

Mortar Qualities

If there are concerns about the quality or uniformity of the mortar used in the existing construction, mortar quality and consistency throughout the building may be evaluated and compared using a rebound hammer, which measures the amount of rebound of a pendulum weight after striking the mortar surface, similar to the use of a Schmidt hammer device used for testing concrete surface hardness. In addition to surface hardness, knowledge of the mortar characteristics deeper inside the wall may be needed, such as in situations where past repairs or repointing havecovered the original mortar with a different type of material. Resistance drilling techniques have been reported to produce good correlation with mortar compressive strength values, and only require small holes drilled in existing mortar joints.

III. QUALITY & PERFORMANCE

Quality Control

A successful construction or repair project depends on the quality of work performed being as good as it was designed and specified to be. Nondestructive methods such as SPR and IRT are especially useful to determine the effectiveness of repairs such as rebuilding or injection, especially when a "before and after" comparison can be made with the results. Metal detection methods are also helpful for confirming the placement of retrofit anchors or veneer ties without visual observation. The costs associated with these methods are likely to be lower than providing full-time inspections, or opening completed repairs for observation and repeating the repair work.

Structural Monitoring

A good monitoring program can provide peace of mind before, during, and after repairs are conducted. Before deciding which repairs are necessary, structural monitoring can help determine if cracks are active or dormant, and if the building is moving, whether the movement is due to natural weather cycles or something more serious. Monitoring systems that operate on vibrating wire technology feature a central datalogger connected to sensors that are capable of measuring crack width, tilt angle, surface strain, and temperature. The system itself requires only a low power input, so extended longevity is possible with little maintenance. These monitoring systems can be installed using adhesives or small anchors, so the impact to the structure is minimal (Figure 6). During construction, monitoring is useful to determine if the ongoing activity is causing additional building distress or movement. The activity does not necessarily need to originate from your site to affect your structure, either. An adjacent excavation or heavy equipment can affect your building as well.

Figure B

Figure B: Vibrating wire crack monitors used for long-term structural movement monitoring.

After repairs, strengthening, or stabilization work have been completed, a long term structural monitoring program will result in valuable data that will aid in diagnosing future distress, aid in detecting potential problems before they become serious and more expensive to fix and, finally, ease concerns about long term structural performance.

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STRENGTH ANALYSIS OF EXISTING STRUCTURE

PREAMBLE

Detailed appraisal of structure is utmost important which includes examination of concrete structural members for the purpose of identifying and classification of damages/distresses. While it is referred in connection with appraisal of concrete and embedded reinforcement that is showing some degree of distress, its application to all buildings and structures. The system is designed to be used for recording the history of structures from its inception to completion and subsequent life. Condition survey of a building/structure is generally undertaken in four different stages to identify the actual problem so as to ensure that a fruitful outcome is achieved with minimum efforts & at least cost. The four stages of condition survey are:

a) Preliminary inspection,
b) Planning,
c) Visual examination,
d) field and laboratory testing (Non-destructive evaluation and characterization of materials).

To ascertain the residual strength of concrete, it is imperative to assess health of the structure using state-of-the-art non-destructive testing (NDT). The tests are mainly useful in understanding serviceability, adequacy of concrete, subsequently assessing the cause, extent of deterioration of structure and assessment of structural integrity.

NDT was aimed at assessment of condition of structural elements. In NDTs, rebound hammer test and ultra-sonic concrete tests on columns and beams has been carried out. To augment information derived from NDT, quantitative assessment of compressive strength of concrete, coring has also beam carried out at critical locations of the structure tested. Further, a detailed investigation has also been carried out assess the corrosion of reinforcement in the structure using half-cell potential method.

VISUAL EXAMINATION

Visual examination of a structure is the most effective qualitative method of evaluation of structural soundness and identifying the typical damages, distress symptoms together with the associated problems. This provides valuable information in regard to its workmanship, structural serviceability, material deterioration mechanism and helps in preparation of realistic bill of quantities for various repair items.

Number of non-destructive evaluation (NDE) tests for concrete members are available to determine in-situ strength and quality of concrete.

The term ‘non-destructive’ is used to indicate that it does not impair the intended performance of the structural member being tested.

These tests have been put under four categories depending on the purpose of test as under-
1. In-situ concrete strength
2. Chemical attack
3. Corrosion activity
4. Structural integrity/soundness

The methods of testing, instruments used are presented below:
Rebound Hammer Test
Rebound hammer is also called Schmidt hammer, wherein plunger is pressed against the surface of concrete, a spring controlled mass with a constant energy is made to hit concrete surface to rebound back. The extent of rebound, which is a measure of surface hardness, is measure on a graduated scale. This measured value is designated as Rebound Number (a rebound index). A concrete with low strength and low stiffness will absorb more energy and yield to a lower rebound value.
The results are significantly affected by mix characteristics, angle of inclination of direction of hammer with reference to horizontal.

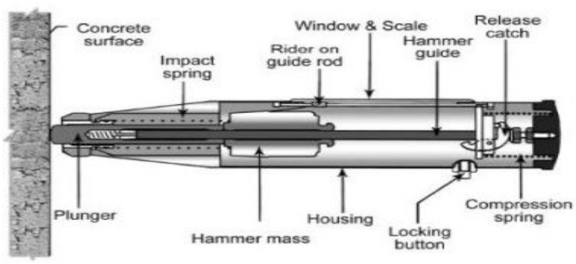

Figure C

Rebound hammer test is done to find out the compressive strength of concrete by using rebound hammer as per IS: 13311 (Part 2) - 1992. The underlying principle of the rebound hammer test is(Fig-6):

The rebound of an elastic mass depends on the hardness of the surface against which its mass strikes. When the plunger of the rebound hammer is pressed against the surface of the concrete, the Spring-controlled mass rebounds and the extent of such a rebound depends upon the surface hardness of the concrete. The surface hardness and therefore the rebound is taken to be related to the compressive strength of the concrete. The rebound value is read from a graduated scale and is designated as the rebound number or rebound index. The compressive strength can be read directly from the graph provided on the body of the hammer.
Procedure to determine strength of hardened concrete by rebound hammer**:**
Before commencement of a test, the rebound hammer should be tested against the test anvil, to get reliable results, for which the manufacturer of the rebound hammer indicates the range of readings on the anvil suitable for different types of rebound hammer.
Apply light pressure on the plunger - it will release it from the locked position and allow it to extend to the ready position for the test.
Press the plunger against the surface of the concrete, keeping the instrument perpendicular to the test surface. Apply a gradual increase in pressure until the hammer impacts. (Do not touch the button while depressing the plunger. Press the button after impact, in case it is not convenient to note the rebound reading in that position.)iv) Take the average of about 5 readings. Interpretation of Results:
The rebound reading on the indicator scale has been calibrated by the manufacturer of the rebound hammer for horizontal impact, that is, on a vertical surface, to indicate the compressive strength. When used in any other position, appropriate correction as given by the manufacturer is to be taken into account.

Table:- Average Rebound number and quality of concrete

Average Rebound Number	**Quality of Concrete**
>40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
< 20	Poor concrete
0	Delaminated

Study, ultrasonic technique is used for assessment of concrete strength quantitatively. In this technique sound waves of ultrasonic frequencies are transmitted through the concrete members to measure the velocity of ultrasonic pulses. The velocity of ultrasonic pulses travelling through the concrete mainly depends on the elastic properties of concrete, which indirectly indicate the strength of concrete. Since, there is no unique correlation between the velocity and strength of

Pulse Velocity (km/second)	Concrete Quality (Grading)
Above 4.5	Excellent
3.5 to 4.5	Good
3.0 to 3.5	Medium
Below 3.0	Doubtful

Fairly good correlation can be obtained between cube compressive strength and pulse velocity. These relations enable the strength of structural concrete to be predicated within +-20 %, provided the types of aggregate and mix proportions are constant. The pulse velocity method has been used to study the effects on concrete of freezethaw action, sulphate attack, and acidic waters. Generally, the degree od damage is related to a reduction in pulse velocity. Cracks can also be detected. Great care should be exercised, however, in using pulse velocity measurement for these purpose since it is often difficult to interpret results. Sometimes the pulse does not travel through the damaged portion of the concrete. The pulse velocity method can also be used to estimate the rate of hardening and strength development of concrete in the early stages to determine when to remove formwork. Holes have to be cut in the formwork so that transducers can be in direct contact with the concrete surface. As concrete ages, the rate of increase of pulse velocity slows down much more rapidly than the rate of development of strength,so that beyond a strength of 2,000 to 3,000 psi (13.6 to 20.4 Mpa) accuracy in determining strength is less than+- 20%. Accuracy depends on careful calibration and use of the same concrete miox proportions and aggregate in the test sample used for calibration as in the structure. In summary, ultrasonic pulse velocity tests have a great potential foor concrete control, particularly for establishing uniformity and detecting cracks or defects. Its use for predicting strength is much more limited, owning to the large number of variables affecting the relation between strength and pulse velocity.

The simplest way to asses the severity of steel corrosion is to measure the corrosion potential, since it is qualitatively associated with the steel corrosion rate. One can measure the potential difference between a standard potable half cell, normally a copper/ copper sulphate (cu/cuSO4) standard reference electrode placed on the surface of the concrete with the steel reinforcement underneath. The reference electrode is connected to the positive end of the voltmeter and the steel reinforcement to the negative. This test can give the probability of corrosion activity taking place at the point where the measurement of potential is taken from a half-cell, typically a copper-copper , sulphate helf-cell. An electrical contact is establish with the exposed steel & the half-cell is moved across the surface of concrete for measuring the potentials.

Concrete Core Testing

While rebound hammer, and ultrasonic pulse velocity tests give indirect evidence of concrete quality, a more direct assessment on strength can be made by core sampling and testing. Cores are usually extracted by means of a rotary cutting tool with diamond bits. In this manner, a cylindrical specimen is obtained, usually with ends being an uneven, parallel and square and sometimes with embedded pieces of reinforcement. The cores are visually examined and photographed, giving specific attention to compaction, distribution of aggregate, presence of steel, etc. The core then should be soaked in water, capped with molten sulphur to make its ends plain, parallel, at right angle and then tested in compression in a moist condition.

The strength of a test specimen depends on its shape, proportions and size. The influence of (h/d) ratio on the recorded strength of cylinder is an established fact. The core should preferably have this ratio near to 2.

The core test provides the visual inspection of the interior of the concrete and direct measurement of the compressive strength. Other physical properties, such as. Density, water absorption, indirect tensile strength and expansion due to alkali-aggregate reaction can also be measured. After strength testing, these can be used as samples for chemical analysis. The procedure has been standardised by BS, ASTM and ACI codes. IS-1199-1959 For Field Core Cutting and IS-516-5.5-1959 for Lab compressive strength.

In core testing. The determination of core size and location is a crucial factor. The test should be taken at pints where minimum strength and maximum stress are likely to coincide. But, at the same time, the core cutting causes some damage to the member and may impair the future performance of the member. Therefore, in slender members, the core should be taken away from the critical section. For compressing testing, the diameter of the core should be at least three times the nominal maximum aggregate size. The accuracy of the test increase with the ratio of core diameter to the aggregate size. The generally recommended length to diameter ratio of the cores is between 1 to 2.

The core sample can be used for determination of unit weight, estimation of voids, and chemical analysis, a graphic analysis and analysis. Broken samples form the cores can be used to determine the pH value and the chloride content in the sample. These tests on cores and core samples will also provide information that can be uses to assess the state of corrosion of reinforcing steel.

CHEMICAL ANALYSIS

For know about the chemical analysis, we can take a example of NegiBhawan, NegiBhawan is located in ONGC campus Dehradun. For assessing the physic-chemical characteristics of the concrete in the building in its present condition samples of core drill from the various locations of Negi-Bhawan were used for chemical analysis. The samples were broken into smaller pieces by hammering. Subsequently, the sieving of samples was done by a suitable IS sieve. The samples were tested at the laboratory for determination of pH value of concrete, chloride and sulphate content.

For determination of pH, the extract of samples has been prepared by adding required quantity of pulverized mortar into distilled water. After 10-12 hours, filtration of samples was done. The pH of extract was recorded with the help of pH meter with single electrode assembly.

The total chlorides estimation in the hardened concrete carried out according to IS 14959 (part2)-2001. A required amount of pulverized mortar was taken and digested with nitric acid. Silver nitrate solution of required normality was added into filtrate and back titrated with ammonium thiocynate using ferric alum as an indicator. The amount of chlorides was calculated from the weight of the sample taken for the extract and percentage reported by the weight of cement in concrete.

The pH of water extract of hardened concrete mortar samples were examined with the help of calibrated pH meter with single glass electrode assembly.

In presence of chloride salt the passivation of steel is destroyed. Chloride ions have special property of breaking the passivity of iron in the alkaline concrete system, thus causing corrosion.

The sulphate content varies between 0.013 to 0.022 % in NegiBhawan. The maximum amount of total sulphate content which is regulated by the amount of tri calcium aluminate of the cement and gypsum added it limits to 3% as per IS 269-1969, which is also well below the permissible limit.

CONCLUSION

A variety of nondestructive and in-situ methods exist to determine material properties and to diagnose problems in existing masonry structures without the need for sample removal. The information gained from a testing program that is well-planned and performed correctly, with results interpreted by experienced professionals, can reduce costly repairs to the concentrated areas where they are needed, and can provide design engineers with confidence about the materials they are working with on any given project.

If we can able to purchase some instrument related to NDT. Then we can grow up in this field and we can able to give the certification of structural stability also.

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