BUILDING INVESTIGATION

When does a building need investigation

1. When defects are visible (cracks, tilting, excessive deformation, etc.)
2. Aging of structure.
3. Change of ownership.
4. Change of use.
5. For planning and budgeting maintenance activities.
6. Post crisis assessment (fire, earthquake, explosion, etc.)
7. Satisfying statuary requirements.

What are the steps of building investigation

1. Document review
2. Visual inspection.
3. Testing, analysis and monitoring.
4. Reporting.

Document review

Review of documents relating to the building including;

1. Design drawings
2. Workshop drawings
3. Soil report
4. Construction specifications
5. As-built drawings
6. Construction reports
7. Material testing and quality control reports
8. Maintenance reports
9. Previous inspection and repair reports

Visual inspection

Visual inspection is the most important step in building investigation, since it identifies the scope of the and the types of problems that exist in a building. Visual inspection also provides an initial assessment of the causes of these problems, which determines how the following steps will be conducted.

Visual inspection is done using human senses (sight, touch smell) with the help of simple tools like a tape measures, plumb bob, hammer, etc.

Each section of a building is surveyed, for each section where defects or problems occurs these defects are noted and could be sketched on an existing drawing of the building. photographs are also taken. Photographs are very important in building investigation as they provide an accurate description of the condition of the building. photographs make a report more clear and help anybody other that the person who did the investigation understand the problem.

Additionally the outlines of areas of defects and the ends of cracks are marked and dated. In later visits this provides a base line by which it could be known if these defects or cracks are active and at what rate they increase.

Testing

Destructive testing
Destructive testing are conducted by extracting parts or sections from the structure and testing them to failure using standard material tests.

1. Concrete core test
   A cylindrical core is extracted and tested in order to measures strength of concrete. After testing the specimens could also be used for chemical analysis.
   If the cylinder height to diameter ration is not equal to 2 adjustments must be made to the results.

Concrete coring machine

Concrete core specimen

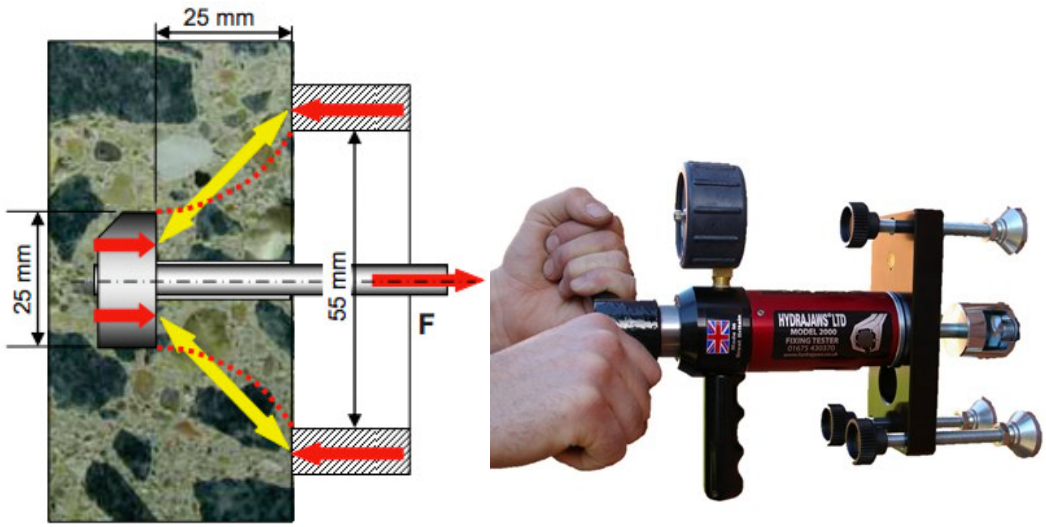
2. Steel coupon and rebar tension tests
   To measure the properties of steel members and reinforcement bars like strength and modulus of elasticity

When taking samples from a structure care must be take so that the extracted specimens does not affect the stability and the strength of the structural member from which it was extracted from.

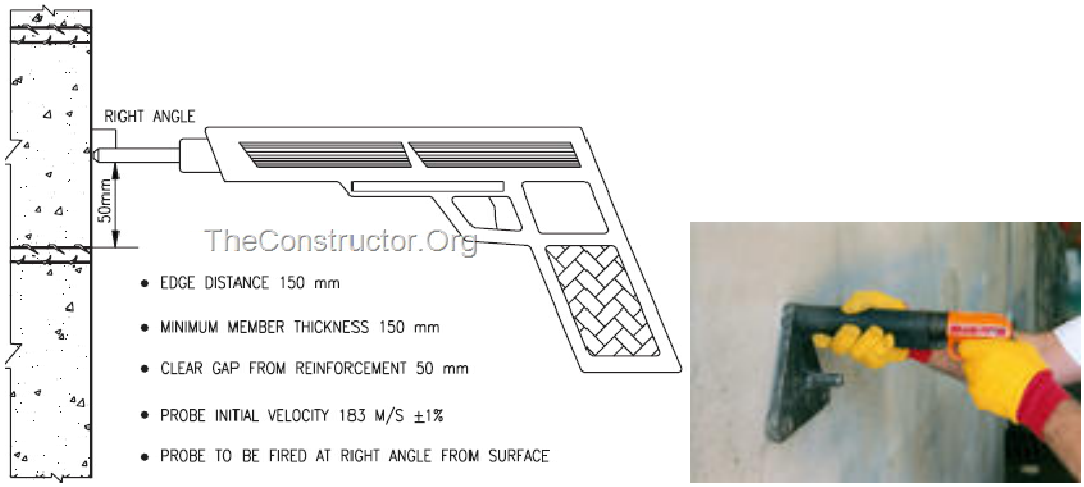
Semi-destructive tests

Semi-destructive tests are tests that are conducted to provide some indication of the to the material properties by causing superficial damage to the structural member's surface.

1. Concrete pullout test
   Used to estimate the strength of concrete by determining the force required to extract part of the concrete giving an indication of its tensile strength.



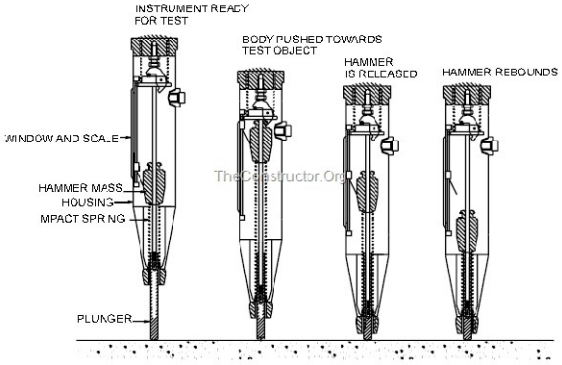
2. Windsor probe test
   Used to estimate the strength of concrete by measuring the depth which the device penetrates the concrete.



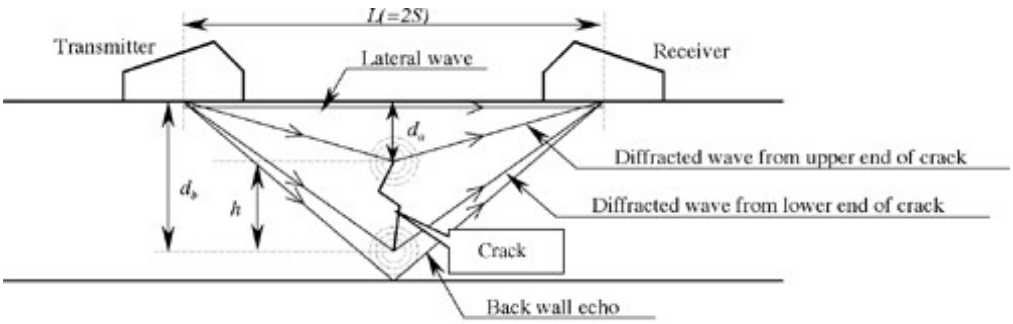
Nondestructive tests

These are tests that do not cause any damage to the structure.

1. Rebound hammer test
   Used to estimate the strength of concrete by measuring the force of the rebound from the hammer. Denser concrete will have more strength and rebound.
   This test is not very accurate with errors reaching 50% for weak concrete.



2. Ultrasonic test
   An ultrasonic pulse is emitted from a transmitter at one end and received at the other. The speed of the pulse will depend on the density of the material which give an indication about its quality. Also the presence of defects like cracks and voids will cause the waves to scatter and reflect, which effects the signal at the receiver. This signal could then be analyzed to determine the location of defects.



3. Gamma radiation test
   Used to estimate the density of concrete and also the location of reinforcement bars and internal voids and cracks.
4. X-ray test

Used in the same way as the gamma radiation test and is used to find defects in welds.

5. Electromagnetic cover meter
   Used to find the location of reinforcement bars and estimate their diameter or the cover.

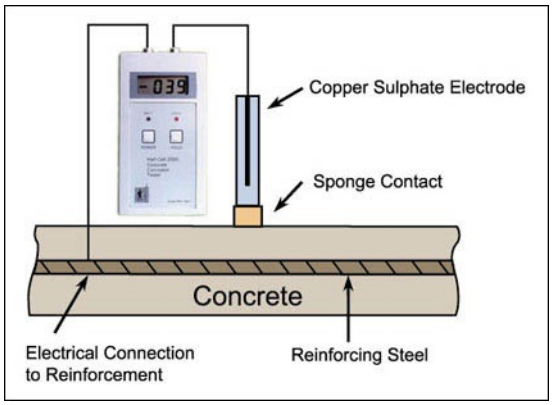
Semi-destructive and nondestructive test give a good indication about the material properties. They are easier to perform, cost less and therefore could be used for a large number of points in the building. However they lack accuracy to a certain degree, and can only give an indication to the strength of the material but not an accurate estimate that could be used for design purposes.

Destructive testing however are accurate but expensive and cause minor damage to parts of the building and therefore could be used in a limited number of points.

The best strategy is to combine destructive and nondestructive or semi destructive testing. By performing a large number of nondestructive test and a smaller number of destructive tests on some of the same points that were tested using nondestructive or semi destructive tests and use the results of the destructive test for a more accurate correlation of nondestructive or semi destructive tests

Chemical tests

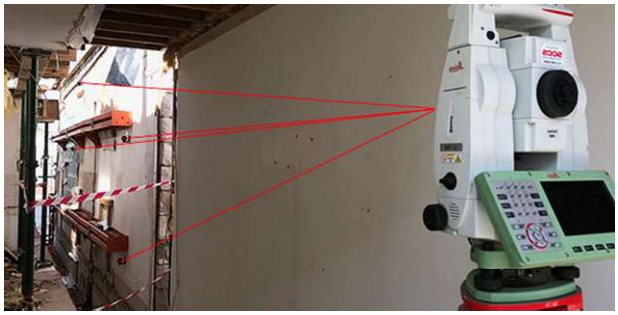
1. Chemical composition of a material
2. Amount of sulphates and chlorides
3. Cement content
4. Carbonation depth
5. Halfcell potential test
   Used to find the potential for corrosion in reinforcement bars.



Monitoring

Monitoring is conducted to see if cracks and other defects are active and what are their rate of increase. Also in the case of settlement and tilting the building is monitored to determine in the movement is continues of not and whether it is increasing or decreasing.

Crack meter



Monitoring settlement

Load tests

Load tests are conducted on buildings or parts of a building. Loads are applied using water bags, sand bags, blocks and in the case of bridges using loaded trucks.



Applying loads on bridges


Applying loads on bridges

The total applied load during testing should be about 85% of the design load, i.e.

0.85(1.4 DL + 1.6 LL)

The applied load = 0.85(1.4 DL + 1.6 LL) – existing load

The load should be applied at increments and the deflection and strains are measured at key points are record at each increment.

After achieving full load the load is left for 24 hours if applicable and the final readings are taken.

The load is removed and the residual deflections and strains are measured.

The total deflections should not exceed code requirements or values that were previously calculated in a detailed structural analysis

After removing the load the residual deflections and strains must not exceed 25% of the total deflections and strains measured during the test

Analysis
A revision of the structural analysis and design may be required in the following cases;

1. Obvious design mistakes
2. Wrong assumptions in original analysis or design
3. Original analysis and design documents were unavailable
4. Original design and analysis overlooked some load cases
5. Appearance of several overloading defects
6. Increased loading or planned load increases
7. Actual member sizes are different than design drawing
8. Actual material properties were different than design
9. Reduction in structural member sizes or properties due to deterioration

Revised analysis includes

1. Revision of original structural analysis and its assumptions or conducting a structural analysis if the original analysis was unavailable.
2. Conducting independent more complex or detailed structural analysis, e.g. 3D analysis, P-Δ analysis.
3. Conducting an analysis that includes effects that were overlooked in the original analysis like temperature effects.
4. Conducting an analysis that includes actual material properties and sizes

Revised design includes

1. Revision of original design
2. Design check based on revised structural analysis, material test data, or actual member sizes.
3. Design check based on updated codes or loads

Reporting

Introduction
This section provides a brief note about building and why the report was prepared and to whom it was prepared for.

Description of the building
This section describes the building's

1. Location
2. Usage
3. Dimensions
4. Height and number of floors
5. Neighboring structures
6. Structural system
7. Brief history of the building

Visual inspection procedures and results
This section provides a detailed description of the visual inspection procedure and observations of each section of the building.

Testing and test results
This section provides detailed description regarding the tests and their results including;

1. Types of test that were performed
2. The specifications according to which these tests were performed
3. The number of tests or test specimens and the location where the test were performed or the specimen were taken (sometimes a drawing indicating the points is provided)
4. The results of the tests
5. The final results could be summarized in the form of a table with one or two typical curves shown the rest could be added in an appendix
6. The indication of each test result

Conclusions and recommendations
This section provides a description of the problems or defects the building have and what are their causes. This section also provides what are the possible solutions to these problems.