BUILDING PATHOLOGY & INSPECTION  Unit 3
Introduction to Building Diagnostics
Introduction to Building Diagnostics

3.1 Learning outcomes

- Define the key terms involved in Building Pathology.
- Anticipate, recognise and identify the degradation of building materials, components and elements.
- Identify and apply the basic diagnostic process for investigating defects.
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3.2 Building Pathology

Building Pathology was promoted by the International Council for Research and Innovation in Building and Construction.

Building Pathology under CIB commissions; WO86 has the following objectives:

- Produce information that will assist in the effective management of service loss.
- Develop methodologies for assessment of defects and failures and consequential service loss.
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3.2 Building Pathology

- Apply systematic approaches to the investigation and diagnosis of defects and failures in buildings of all types and at all stages of life.

- Audit buildings in use to check the veracity of service loss prediction.

- Promulgate findings to all those involved in the production and management of buildings.
3.2 Building Pathology

The landmark Latham (1994) and Egan (1998) reports highlighted the need for construction industry to increase its efficiency and suggested ways of achieving this.

Due to the need to achieve, time, budget and zero defects, building pathology has become an increasingly important part of the construction process.
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3.2 Building Pathology

In 1994 the Latham Report 'Constructing the Team' was published. The report was commissioned by the UK government to investigate the perceived problems with the construction industry, which the report's author, Sir Michael Latham described as ‘ineffective’, ‘adversarial’, ‘fragmented’ and ‘incapable of delivering for its customers’.

In 1997, the then Deputy Prime Minister John Prescott set up the Construction Task Force, chaired by Sir John Egan. In 1998, the task force published ‘Rethinking Construction, The report of the Construction Task Force specific on the scope for improving the quality and efficiency of UK construction’. It is generally referred to as the Egan report.
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Therefore to reduce the number and incidence of building failures we practice the followings:

- Increase the sustainability of buildings.
- Achieve buildings that offer better value for money.
- Reduce hazards and accidents in buildings.
- Combat poor indoor air quality.
- Minimize negligence and other legal consequences in construction.

RICS & ABE actively incorporated Building Pathology in their list of competences as a core area of skill and knowledge for Building Surveyors. It is now a key subject area in the advanced stages of most if not all Building Surveying degree courses.
3.2 Building Pathology - The principal components of building Pathology are as follows.

Figure 1 Hierarchy of Building Pathology
3.2 Building Pathology - Figure below illustrates sub domain of Building Diagnostics.

**Figure 2 Hierarchy of Building Diagnostics**
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3.2 Definitions

- **Building Pathology**: CIB defines Building Pathology as the *systematic treatment of building defects*, their *causes* (aetiology), their *consequences* (hystology) and their *remedies* (therapy).

- **Defect**: A situation where one or more elements *do not perform its/their intended function*. It is also classed as a shortfall in performance, statutory or user requirements of a building material, component or element.

- **Degradation**: Refers to deleterious effect of sunlight.

- **Diagnosis**: An *impartial assessment* based on *experience and knowledge*, of all the data available to determine the root cause of a problem.
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3.2 Definitions

- **Durability**- the ability of the building that can withstand over a period of time and the *measurement resistance to deterioration*.

- **Failure**- the *termination of the ability* of an item to perform a required function. It can also be classed as the consequence or effect of a defect.

- **Fault**- an *unexpected deviation from requirements*, which would require considered action regarding the degree of acceptability. It is also considered as a *departure from good practice*.

- **Prognosis**- a technical assessment of the *probable course and outcome of a building defect*.
3.3 Agencies causing defects

Defects in buildings are usually due to the use of materials in an inappropriate environment or the use of defective or damaged materials.

Failure due to agency are categorized as either human or natural.
3.3.1 Human factors

**Design & specification**
- **Poor detailing** - ineffective or inappropriate detailing can result in poor protection to building elements. Ex. waterproofing
- **Inappropriate specification** - wrong material is specified causes materials reaction. Ex. aluminium & copper

**Construction**
- **Poor workmanship** - poor training or lack of diligence in installation may result in defective works. Ex. Inappropriate mixing of clay bricks & concrete blocks
- **Inadequate supervision** - poorly or un-supervised sites can result in poor workmanship not being picked up and subsequently ‘built-in’. Poorly stored and transported materials which become damaged and incorporated within the building.
3.3.1 Human factors

Products

- **Faulty manufacture** - faulty or defective materials can lead subsequently to defects within the completed structure. Ex. Defective or faulty sarking underlay can lead to water ingress.

- **Inadequate delivery and/or storage** - materials damaged either by transporting to or by ineffective storage on site which are used to incorporate within the building which lead to inherent defects.
3.3.2 Natural factors

Building defects can arise as a result of exposure to natural agencies including the elements such as rain, snow, solar radiation air bound contamination like dirt, tar, salts and biological factors such as fungi and insects.
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Figure 3.1 Proportion of building defects arising from natural factors
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3.3.2 Natural factors

- The highest proportion of defects comes from moisture where water being the principal agency of deterioration.

- Water acts as catalyst for chemical reaction- as wet building materials can create expansion due to freezing condition which can lead to movement.
3.3.2 Natural factors

- **Moisture** – moisture can affect old and new buildings and may cause deterioration whether it manifests as a liquid (water), gas (water vapour) or as a solid (ice).

  It usually leads to secondary damage e.g. rotting of timber, mould growth on internal linings and reduce thermal performance.

  **Remedy** - the primary source of moisture source need to be addressed.
3.3.2 Natural factors

- **Bio-chemical**: growth of fungal e.g. wet and dry rot and insect attack which affect organic materials such as timber. **Remedy**: require specialist involvement and resolution of moisture source.

- **Movement**: building movement can result from a wide range of factors, e.g. temperature, moisture, settlement or subsidence, structural loading, impact or catastrophic loading, may have short or long term implications. Any cracks wider than 25mm is considered significant movement. **Remedy**: to monitor over time on influencing factors as to determine the extent of movement.
Atmospheric Pollution

The most damaging type of pollutants are the acidic pollutants which are formed when the oxides of carbon, sulphur and nitrogen react with moisture or water to form sulphuric acid.

The phenomenon called Sulphation is a characteristic of large cities and industrial areas using sulphurous fuels. Sulphation causes fissures in materials.

Chloridation commonly occurs in buildings that are situated in coastal areas. Onshore wind and fog carry minute particles of sodium chloride which are deposited on walls and roofs, crystallise and dissolve there and are carried down to lower or deeper levels of the building where they crystallise again, setting up powerful mechanical stresses. Sodium chloride is often the cause of continuous corrosion in metals.
Organic Growth

Buildings that are exposed to temperatures ranges of 25 to 30 degrees Celsius and relative humidities of 70% and above are susceptible to chemical disintegration and biological attack.

Chemical disintegration occurs when moisture is present in the material, accelerated by the rise in temperature. Where there is moisture, cryptogamic growth, bacteria and insects flourish. Biological agents which cause deterioration include vegetation - lower and higher plants, micro-organisms (cryptogamic growth) insects and other animals.

The lower form of plants grow on broken rock, die in dry weather and then again proliferate forming humus on which higher plants grow. The roots of these plants infiltrate and act as a wedge, dislodging the mortar from the joints, loosening the blocks and causing fissures.
Water is considered a major cause of material deterioration. It could penetrate materials by capillary rise from the ground or through the surface from atmospheric moisture and rains. Water is responsible for the fissures and cracks in stones, growth of insects and micro-organisms in wood, and corrosion of metals.
Rain/Snow/Hail

- Moisture is the greatest cause of deterioration in building materials
- Rising damp can cause flaking and cracking
- Frozen water can cause stresses and cracks
- Moisture can promote rust in metals
- Moisture creates an environment for fungal growth as well as insect attack
- Build up of snow or ice on roof structures can increase the loading
Example of Incompatibility

- Galvanic corrosion (also called “dissimilar metal corrosion”) is corrosion damage that occurs when two dissimilar materials are coupled in a corrosive electrolyte.

- When a galvanic couple forms, one of the metals in the couple becomes the anode and corrodes faster than it would by itself, while the other becomes the cathode.

- Corrosion of a cadmium plated washer in contact with a stainless steel screw.
Biological Attack

Timber is at risk of attack from a range of organisms if it remains damp or wet for extended periods - various species of fungi and insects are the principal risks in buildings in the UK.

Fortunately these risks are manageable and, with proper specification, detailing and maintenance, should be preventable. There is little risk of fungal decay if timber is dried to, and then maintained at, a moisture content below around 20%.

- A converted warehouse in Scotland is supported on wooden piles which are exposed to attack from marine borers and specialised fungi. The timber cladding, although close, is at much less risk of biological degradation.
Biological Attack

Wet rot - *Coniophora puteana*
Commonly know as the cellar fungus

**Habitat:**
Found in softwoods and hardwoods. This is the commonest cause of decay in woodwork which has become soaked by water leakage.

**Damage characteristics:**
The wood darkens, with cracks along and across the grain, but usually less deep than those caused by *Serpula lacrymans*. Where conditions cause the wood surface to dry, there may be an apparently sound skin of timber which may crack longitudinally as the decay progresses beneath. Freshly colonised wood usually shows a yellow colouration.

**Fungal characteristics:**
- **Mycelium** - Only present in conditions of high humidity. Yellow to brownish in colour, off-white under impervious floor coverings. May spread superficially over damp plaster or brickwork.
- **Strands** - Are thin, usually brown to black, though yellowish when young.
- **Fruit-body** - Is rare in buildings. Thin, lying flat on substrate and with small irregular lumps. Olive green to olive brown with a cream margin, paler when young.

*Coniophora puteana* - typical damage

*Coniophora puteana* - freshly colonised wood showing distinctive yellow colouring

*Coniophora puteana* - strands (left) and fruit-bodies (above)
Hydro-Thermal

Condensation is a process whereby water is deposited from air containing water vapor when its temperature drops to or below dew point, temperature at which air becomes saturated with water vapor.
Stress - Shrinkage

Shrinkage cracks in poured concrete are easily recognizable and can be distinguished from other types of cracks that occur later in the life of a foundation wall or floor slab.

- The photograph of cracks above were taken of shrinkage cracks in a concrete slab floor in a home built in 2006. The cracks in this case ranged in width (measured across the crack) from "hairline" (in the basement floor slab of this particular home. They may appear larger.

- What is unique about shrinkage cracks in concrete is that they usually appear to be discontinuous, as shown in this photo. The crack will meander along in the concrete, taper to a stop, and then continue beginning in a parallel line to the first crack, meandering again through the concrete.

- This is characteristic of concrete (or mud) shrinking while giving up its moisture.
Stress - Expansion

- Thermal expansion failures in structural or veneer brick walls

- Brick "grows" in size indefinitely [though probably most of its size increase is early after it's manufacture].

- But a separate factor that can cause very large movements and extensive damage to brick structures or brick veneer walls is the thermal expansion which occurs across a long or tall brick wall when that wall is heated by sun exposure. The photographs here show significant thermal expansion damage in a long brick structure.
Figure above shows examples of how specific risks may be analysed or assessed.
3.4 Investigative approaches

The chart attempts to assess 3 keys defects risk area Dampness, Bio-decay and Cracking in a systematic ways step by step by categorizing the discovered defects which will then lead to a diagnosis of the problem and recommendations for remedial action.

There are number of deductive techniques or investigation approaches that surveyor practice.
3 Key Defect Risk Areas

Biodecay

Movement

Dampness

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3 Key Defect Risk Areas

Type? Risk? Remedy?
3.4.1 The deductive (Detective) approach

Figure 3.3 Deductive approach

<table>
<thead>
<tr>
<th>Detective approach</th>
<th>Building surveying approach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VICTIM</strong></td>
<td>The building, an element or more of its many components</td>
</tr>
<tr>
<td><strong>CRIME</strong></td>
<td>The detect, although initially this may only be manifest as anomalies or minor deviations re indications.</td>
</tr>
<tr>
<td><strong>SUSPECTS</strong></td>
<td>Detective or damaged materials, poor workmanship or detailing, aggressive or exposed natural environment.</td>
</tr>
<tr>
<td><strong>DIAGNOSIS</strong></td>
<td>Inspection, monitoring and tests confirm primary and secondary causes.</td>
</tr>
<tr>
<td><strong>CLOSURE</strong></td>
<td>Recommendation for remedial action, monitoring and maintenance.</td>
</tr>
</tbody>
</table>
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3.4.1 The ‘HEIR’ approach

- E: Examine the subject property.
- I: Investigate the symptoms.
- R: Response- evaluation and treatment.
3.4.1 The defects diagnosis process

Recognition (Observation & Critical Thinking)
- SYMPTOMS
- CONDITION

Diagnosis (Analysis & Problem Solving)
- CAUSE/S
- EFFECTS

Treatment (Synthesis & Decision Making)
- REMEDY

- DISTORTION? DISCOLOURATION? DEGRADATION?
- BAD? POOR? FAIR?
- DAMPNESS? BIODECAY? MOVEMENT?
- DAMAGE? INSTABILITY? DISFIGUREMENT?
- THERAPY

DEFECTS DIAGNOSIS PROCESS
3.5 Conclusion
The objective is to introduce the basic concepts of building diagnostics
1. **Identifying** key factors involved in building defects.
2. Appreciate the principal agencies involved in material degradation and how they manifest in buildings.
3. **Basic diagnosis** procedures for investigating defects. **Identify symptoms** and provide **remedial actions**.

All diagnostic procedure follow a similar process
1. **Recognition** or identification of a series of symptoms.
2. The **diagnosis** or the assimilation and analysis stage, which involves the identification of the cause of the defect.
3. **Remedial stage**, involving an assessment of works or actions required to remove or reduce the effect of the defect.