BUILDING PATHOLOGY & INSPECTION

Unit 4

Building Deterioration
4.1 Learning outcomes

- Describe and apply the main methods of service life prediction to building elements and components.

- Identify and assess the main sources and effects of damage to buildings.

- Prescribe appropriate remedies for damaged buildings and identify measures to make them more “future-proof”.

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4.2 Introduction

Building pathology includes the study and prediction of the effects of deterioration, and as a consequence: the building life and its durability.

Deterioration is universally defined and inferred to as a ‘worsening condition’
4.3 Through life issues

- **Durability** - is the *ability* of a material component or building system to resist the effects of deterioration.

- **Changeability of buildings** - *negate* the need for large factories, lack of maintenance

- **Service life prediction** - service life of *material or component*

- **Whole life costs** - cradle to grave *costs & revenues*

- **Maintenance cycles** - undertaken during service life
4.3 Through life issues

- Shearing layers of change- view buildings as a set of components that evolve in different timescales. The layers as follows:
  - Site- geographical, location, legal plot, boundaries.
  - Structure- the foundations and the frame.
  - Skin- the façade.
  - Services- M&E, HVAC.
  - Space plan- interior layout.
  - Stuff- furniture and fittings.
  - Souls- the occupants.
4.4 Deterioration mechanisms

The performance of fabric of a building is reduced or undermined by 2 primary influences:

- **Climatic agencies** (environmental influences)- *external influences* such as rain and snow.

- **User activities** (functional influences)- *internal influences* such as misuse or poor maintenance.
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The following list highlights the key deterioration mechanisms:

- **Chemical** - juxtaposition of incompatible materials or contamination close to building.

- **Solar radiation** - absorption of infra-red radiation results in surface temperature increase resulting to movement of material leading to cracking and crazing.

- **Mechanical** - impact in surface resulting to wear and tear and extreme cases cracking and deformation of wearing surfaces.

- **Biological** - attack by moulds, fungi and insects to timber products due to damp and stagnant conditions.
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The following list highlights the key deterioration mechanisms:

- **Hygro-thermal** - moisture and temperature work together to create an aggressive environment, e.g. condensation. Freezing of water causes expansion in building materials once temperature drop below zero.

- **Stress** - material movement that are restraint due to shrinkage or expansion, the stresses can result to serious disruption e.g. cracking, splitting, bending or deflection. Stress from dead and live loads within buildings could affect the structural elements.

- **Use** - natural wear and tear and lack of regular maintenance will result in deterioration and reduce life span.
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Deterioration Rates

- TIME RELATIONSHIPS
- BATH-TUB FAILURE RATE
- DIFFERENT FORMS AGEING
4.5 Rates of deterioration
4.5.1 Different types of ageing

All materials, products and components age, figure below is a graphical representation of different types of ageing.

1. Ideal performance profile - there is no drop off in performance over the life of the product. However due to natural deterioration, ageing and use this is unobtainable.

2. Abrupt - sudden failure following a period of slow linear deterioration in performance over time. Associated with building services materials and systems.

3. Linear - typical failure of building materials which perform effectively and deteriorate over a fixed period of time.

4. Exponential - this is typified by a slowing up of the rate of deterioration over the service life of the product.

5. Minimum acceptable standard - a level of life expectancy which must be obtained either due to economic, social, environmental or practical reasons.
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4.5.2 Deterioration and time relationships
Highlights the deterioration over time relationship for maintained and unmaintained buildings. The points A through D represent the stages of accelerated deterioration. The structures which has been repaired at point A cost less and last longer than the structures left and maintained at B.
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4.5.3 ‘Bath tub’ failure
The bath tub represents the typical service life model for many components or systems (buildings). In the early stages of life there is potentially a high risk of failure which level off, increasing again towards the end of the service life. Figure 4.3 shows the ‘bath tub’ failure.
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4.5 Service life assessments
Service life assessment is typically defined as:

- A methodical approach to predicting the durability of materials and components. **PREDICTION**

- A structured, traceable method to manage the risks inherent in construction procurement. **RISK MANAGEMENT**

- A mechanism for information management which allows the involved parties to learn from best practice and poor performance. **EXPERIENCE**

- A system to demonstrate value for money in construction procurement. **VALUE**

- A method to assess the implication of variations during the project and mitigate the impact of such variations. **CHANGE**
4.5.1 Types of service life

- **Aesthetic** - looks of the building can influence the overall service life. Wear and tear of the building fabric can have detrimental effect on appearance, thereby affecting the user’s perception of quality and enjoyment.

- **Physical** - as materials, components or systems become defective or require increasing maintenance to remain effective they are considered to be approaching the end of their service life.

- **Economic** - commercial or economic decisions can determine the effective life span of the building. Low rise building can be demolish to make way for high rise development. Refurbishment of conservation building could be more costly then re-building new ones.

- **Design** - the service life of the building is design to meet clients intended requirements without over or under design and create low operation cost.
4.6.2 Sources of service life data

- **Experience** – using knowledge and experience to understand various building properties behaviour on their life span.

- **Modelling** - using computer mathematical or small scale testing to simulate the prediction performance of the building. The information generated by modelling can be limited by the accuracy of existing data and the assumptions made by the modeller.

- **Testing** - the routine and standard testing of materials and components to obtain typical properties from which service life predictions can be made and compared.
4.6.3 Methodology for determining service life

- Identification of key criteria: in order to determine or predict service life, a number of data need to be collected, assessed or considered. There are as follows:
  - **Performance characteristics** - the requirements of the clients such as materials, quality, performance, life span.
  - **Exposure conditions** - the environmental conditions which will be experienced over the life of the building.
  - **Site examination** - the local location; topography; natural exposure; proximity of aggressive environments.
4.6.3 Methodology for determining service life

- Tests:
  - the undertaking of routine tests and the collection of standard performance data or data or result which allow the comparison between similar components and exposure regimes and the subsequent prediction of service life.
  - also provides an indication of the limits of performance which enables the designer to provide protection to the building to ensure service life is achieved.
4.6.3 Methodology for determining service life

- **Diagnosis** - by examining current or existing building performance and in particular failures, which highlight limits of performance, the designer can more accurately predict expected performance.

- **Prognosis** - the prediction or forecast of a likely course of events. Having gathered data on existing condition or performance the designer is able to make an educated prediction or forecast of future performance.

- **Therapy** - the treatment or remedial action proposed to reduce or remove the effects of a disorder or defect. Proposals which may improve or enhance the performance of a component or which may provide a solution to an existing defect or failure.
4.7 Damage to buildings

Objectives is to identify the main sources of damage to building and to predict and assess the impact on the performance of the building.

- **Significance of damage:**
  - Safety- any results to unsafe building structure.
  - Security- any results to reduce security of building, which allow easy access to the building.
  - Deterioration- any results to increase to deterioration of the building fabric.
  - Failure- any results in collapse or failure of a principal structural component or the building itself.
4.7 Damage to building

- Sources of damage
  - **Storm**- act of mother nature, violent winds with heavy rain and snow can induce live loads on the building which exceed the design limitations.
  - **Fire**- consumption of combustible materials in an oxygen rich atmosphere resulting in the complete destruction of these combustible materials and the depositing of sot on surfaces throughout the building.
  - **Flood**- flooding due to rising ground water, adverse weather conditions and defective building service.
  - **Others**- earthquakes, impact damage; birds; plants and creepers and vandalism.
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4.7.1 Fire damage to buildings

Principal causes:
- Arson
- Electrical faults
- Sparks
- Chip pan
- Lightning
- Hot working process

Effects & remedies:
Damages: Complete removal of combustible components; melting or distortion of plastics or low melting points materials and extensive soot or contamination damage throughout the building.
Remedies: extensive removal of damaged or contaminated materials and replacement with new. Specific inspections of major structural components will be required.
4.7.2 Flood damage to buildings

- **Sources**: water entering building through natural means or through defective internal and external building services.
- **Issues**: damage by flood causes contamination from ground salts; sewerage, fuel oil or diesel from underground storage tanks or interceptors.
- **Effects**: saturation of porous materials such as masonry and timber and finishing materials.
- **Accumulation of dirt, salts & debris**: detritus and materials, due to flood water which evolved overtime if not treated or resolve after occurred.
- **Corrosion of metals**: moisture ingress can lead to corrosion, rusting and deterioration of metal components. Require extensive refurbishment or removal.
- **Bio-deterioration**: timber & organic materials which extensive contact with water are subject of attacks from moulds and lichens can result in deterioration. Drying & ventilation restriction can lead to moist material (dry rot).

**Remedial actions:**

- Pumping out bulk water: removal of water by conventional pumps.
- Removed damaged items: removal of damaged items and offer replacement.
- Promote rapid drying out: upon water subsided or pumping out, the building is dried out as quickly as possible by industrial heaters & de-humidifiers, continuous frees flow ventilation may be required for weeks and/or months after flooding.
4.7.3 Assessing damage to buildings

Assessing damage to a building involves a two-stage process. **Stage 1**: desk top study, involves a serious of tasks or exercises to ascertain the facts leading to the reported damage. **Stage 2**: on-site investigation involves confirmation and assessment by observation and measurement of the reported damage.
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4.7.3 Assessing damage to buildings

- Stage 1-Desk top study:
  - Nature of damage- 3rd party on-site investigation reports.
  - Timing & location of incident- confirmation from reliable or traceable sources of specific details of the incident. E.g. weather or geological centres.
  - Initial loss assessment- an approximation of potential remedial actions from tradesmen on site or from non-expert tenants.
  - Feedback from experts- confirmation of initial reports or detailed expansion on specific areas of concern.
  - Insurance requirements- notification to insurance company for damage claims. Insurance company may engage independent assessor to investigate the case if dispute arises. Which will require 3rd party expert/specialist reports.
  - Notify HSE- damage of building arising from work activities will need to inform HSE as necessary.
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4.7.3 Assessing damage to buildings

- Stage 2- On-site investigation:
  - Check unsafe parts of the structure- checking high level elements with safe working mechanical equipment.
  - Make site reconnaissance- a detailed walk around the site, including observation from adjoining or neighboring property.
  - Take photographs- photos and videos captured on digital equipment and viewed and assessed in office.
  - Ascertain extent of damage- gather information; assess observations; assimilate and fully understand data in order to fully ascertain the extent of damage. Serious damage can be small problem and minor damage can lead to serious problem.
4.7.4 Procedure for organising remedial works

- Prioritise safety & security measures- ensure damaged areas of building is safe to assess and work. All necessary safety precautions should be taken seriously.
- Clear away debris & other waste- clear away debris and waste material prior to remedial work.
- Ascertain extent of repairs- ensure extent of location of works is clearly defined and measured prior to works in order to prevent over or under working of remedial works.
- Recommend appropriate actions- prepare report of recommended remedial works based on findings.
- Prepare specification- define works based on a structured, recognised system of specification, to ensure that the contractors and specialist sub-contractors fully appreciate extent of works,
- Obtain approvals- ensure all relevant planning, building control and local authority access approvals are certified well in advance of works starting on site.
- Implement remedial works- undertake works having prepared the relevant risk assessment and method statement for the proposed activities.
4.8 Conclusion

1. The service life of building is subjected to the use of building components and system and it is beyond the control of the user in terms of topography, exposure, and environmental conditions.

1. Deterioration area can be a direct result of general wear and tear and vandalism.

1. Data from current experience, standard tests and modelling can contribute to predictions.

1. The surveyor should understand that performance life of a building should not necessarily be determined by fashion, economic factors or technological change.

1. Building surveyor need to record accurately observations and prepare a specification for remedial work appropriately.

1. Damage to buildings can be result from a numbers of common factors, e.g. fire, flooding and remedial treatments must take account of these factors and the need for continuing treatment.