MANAGING BUILDING PATHOLOGY AND MAINTENANCE

Malcolm Thomas

Belgium, Poland, 2013

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.
MANAGING BUILDING
PATHOLOGY
AND MAINTENANCE

The monograph scientifically edited
by Pawel Nowak

Warsaw, Brussels, December 2013
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Print and cover: Drukarnia Oficyny Wydawniczej Politechniki Warszawskiej, tel.: 22 234 55 93
This manual is part of the Construction Managers’ Library – a set of books related to the wide area of management in construction. The books were created within the Leonardo da Vinci (LdV) projects No: PL/06/B/F/PP/174014; 2009-1-PL1-LEO05-05016 and 2011-1-PL1-LEO05-19888, entitled: “COMMON LEARNING OUTCOME FOR EUROPEAN MANAGERS IN CONSTRUCTION, phases I, II and III – CLOEMC).” Warsaw University of Technology, Civil Engineering Faculty, Department of Construction Engineering and Management was the Promoter of the Projects.

The following organisations were Partners in the CLOEMC I Project:
- Association of Building Surveyors and Construction Experts (Belgium),
- Universidad Politécnica de Valencia (Spain),
- Chartered Institute of Building Ireland (Ireland),
- Polish Association of Building Managers (Poland),
- Polish British Construction Partnership Sp. z o.o. (Poland),
- University of Salford (Great Britain),
- Chartered Institute of Building (Great Britain).

The objective of this project was to create first, seven manuals conveying all the information necessary to develop civil engineering skills in the field of construction management.

The following manuals have been developed in CLOEMC I (in the brackets you will find an estimate of didactic hours necessary for mastering the contents of a given manual):
M1: PROJECT MANAGEMENT IN CONSTRUCTION (100),
M2: HUMAN RESOURCE MANAGEMENT IN CONSTRUCTION (100),
M3: PARTNERING IN CONSTRUCTION (100),
M4: BUSINESS MANAGEMENT IN CONSTRUCTION ENTERPRISE (100),
M5: REAL ESTATE MANAGEMENT (100),
M6: ECONOMY AND FINANCIAL MANAGEMENT IN CONSTRUCTION (240),
M7: CONSTRUCTION MANAGEMENT (100).

The manuals created for the purposes of the library are available in three languages: Polish, Spanish and English. The manuals may be used as didactic materials for students of postgraduate courses and regular studies in all three languages. Graduates from the courses will receive a certificate, which is recognized by all organisations – members of the AEEBC, association of construction managers from over a dozen European countries.
Polish representative in the AEEBC is the Polish Association of Building Managers, in Warsaw.

Partners of the CLOEMC II project were:
- Technische Universität Darmstadt (Germany),
- Universidade de do Minho (Portugal),
- Chartered Institute of Building (Great Britain),
- Association of European Building Surveyors and Construction Experts (Belgium),
- Polish British Construction Partnership (Poland),

Within the second part of the project the following manuals were developed:
M8: RISK MANAGEMENT (130)
M9: PROCESS MANAGEMENT – LEAN CONSTRUCTION (90),
M10: COMPUTER METHODS IN CONSTRUCTION (80),
M11: PPP PROJECTS IN CONSTRUCTION (80),
M12: VALUE MANAGEMENT IN CONSTRUCTION (130),
M13: CONSTRUCTION PROJECTS – GOOD PRACTICE (80),

The manuals were prepared in four languages: Polish, Portuguese, German and English.

Partners of the CLOEMC III project were:
- Technische Universität Darmstadt (Germany),
- Universidade do Minho (Portugal),
- Chartered Institute of Building (Great Britain),
- Thomas More Kempen University (Belgium),
- Association of European Building Surveyors and Construction Experts (Belgium),
- Polish Association of Building Managers (Poland).

Within the third part of the project the following manuals were developed:
M14: DUE-DILIGENCE IN CONSTRUCTION (100),
M15: MOTIVATION AND PSYCHOLOGY ASPECTS IN CONSTRUCTION INDUSTRY (100),
M16: PROFESSIONALISM AND ETHICS IN CONSTRUCTION (100),
M17: SUSTAINABILITY IN CONSTRUCTION (100),
M18: HEALTH AND SAFETY IN CONSTRUCTION (100),
M19: MANAGING BUILDING PATHOLOGY AND MAINTENANCE (100).
The manuals were prepared in five languages: Polish, Portuguese, German, French and English.

The scope of knowledge presented in the manuals is necessary in activities of managers - construction engineers, managing undertakings in the conditions of the modern market economy. The manuals are approved by the European AEEBC association as a basis for recognising manager qualifications. Modern knowledge in the field of management in construction, presented in the manuals, is one of prerequisites to obtain EurBE (European Building Expert) cards, a professional certificate documenting the qualification level of a construction manager in EU. The manuals are designated for managers - construction engineers, students completing postgraduate studies “Management in construction” and students completing construction studies. Postgraduate studies are a recognised program, and graduates receive certificates recognised by 17 national organisations, members of AEEBC.

More information:
- about the project: www.leonardo.il.pw.edu.pl
- about the EURBE CARD: www.aeebc.org
TABLE OF CONTENTS:

CHAPTER 1
INTRODUCTION + LEARNING OUTCOMES .............................................. 11

CHAPTER 2
IMPORTANCE OF BUILDING MAINTENANCE ....................................... 14

2.1 BUILDING LIFE CYCLE AND MAINTENANCE CONCEPTS .......... 14
2.1.1 Maintenance Definitions .......................................................... 14
2.1.2 Life cycle costs and relationship with maintenance .............. 18
2.1.3 Maintenance Strategy and Policy .............................................. 19
2.1.4 Relationship between maintenance management functions .... 22

2.2 ASSET MANAGEMENT AND FACILITIES .................................... 23
2.2.1 Asset management and business plans .................................. 23
2.2.2 Maintenance and asset management plans ............................. 24
2.2.3 Surveys for asset management plans ...................................... 25

2.3 STANDARDS AND EXPECTATIONS ............................................. 27
2.3.1 Setting acceptable standards ............................................... 27
2.3.2 Statutory compliance ......................................................... 28
2.3.3 Functional suitability and use of space ................................. 30

2.4 MAINTENANCE SYSTEMS .......................................................... 31
2.4.1 Risk assessment and maintenance management ................ 31
2.4.2 Reactive vs. planned maintenance ....................................... 32
2.4.3 Identifying maintenance needs .......................................... 33
2.4.4 Prioritising maintenance works ......................................... 35
2.4.5 Delivering maintenance ..................................................... 36

CHAPTER 3
MAINTENANCE TECHNOLOGY ......................................................... 38
3.1 MECHANISMS OF DECAY, FAILURE AND DETERIORATION

3.1.1 Typology of common building defects
3.1.2 Survey, investigation and diagnosis
3.1.3 Repair appraisal and selection
3.1.3 Strategies for prevention and mitigation of defects

CHAPTER 4

PLANNING AND FINANCE

4.1 THE MAINTENANCE PLANNING PROCESS

4.1.1 Planned maintenance programmes
4.1.2 Cost and financial management
4.1.3 Costing and budgets
4.1.4 Cost control
4.1.5 Performance management

CHAPTER 5

MAINTENANCE INFORMATION AND THE ROLE OF IT

5.1 SYSTEMS REQUIREMENTS AND USES

5.1.1 Information for maintenance planning
5.1.2 Specific information for reactive maintenance
5.1.3 Specific information for asset management
5.1.4 Management reporting
5.1.5 Standardisation and data sources

5.2 ASSET MANAGEMENT SYSTEMS

5.2.1 Asset management software
5.2.2 CAFM (computer-aided facilities management) and property management software
5.2.3 Building Information Modeling (BIM)
CHAPTER 6

CONSERVATION, SUSTAINABILITY AND ENERGY EFFICIENCY .....104

6.1 PHILOSOPHY .......................................................................................104

6.2 HERITAGE PROTECTION AND CONSERVATION ......................107

6.3 SUSTAINABLE DESIGN AND CONSTRUCTION .........................108

6.3 ENERGY EFFICIENCY .......................................................................110

6.4 NATIONAL CALCULATION METHODOLOGY AND ENERGY
CERTIFICATION .......................................................................................113

CHAPTER 7

CASE STUDIES ..............................................................................................123

7.1 “TRAINREBUILD” - BELGIUM .............................................................123

7.1.1 “French National Property Owners Association Partnership on
Retrofitting” .............................................................................................127

7.1.2 The KIQ (Kooperation im Quartier) Project in Germany ..........128

7.1.3 EN-zyme Association Italy .............................................................128

7.2 THE BUREAU OF INTERNATIONAL RECYCLING - BELGIUM ..129

7.3 HERITAGE COTTAGE - WALES ..........................................................130

7.3.1 Building repair creating energy efficiency .................................131

7.3.2 Retrofitting for energy efficiency and sustainability ..................132

7.3.3 Analysis of the building .................................................................132

7.3.4 Conclusion ......................................................................................135

7.4 PLANNED MAINTENANCE SURVEY ON A LARGE COLLEGE
SITE - ENGLAND .......................................................................................136

BIBLIOGRAPHY ..........................................................................................141
CHAPTER 1

INTRODUCTION + LEARNING OUTCOMES

Managing building pathology and maintenance is undoubtedly gaining wider recognition as a professional discipline across European Union states, given the growing size and aging nature of the built environment, increasing expenditure on maintenance and renovation, and because of the wider dissemination of good practice. The AEEBC (Association of European Building Surveyors & Construction Experts - whose members advise property owners and users on the design, production, development, refurbishment, maintenance and repair of their properties - have been at the forefront in campaigning to unify the building professions of Europe in the management of building pathology and maintenance. Their aim is not to seek harmonization but to establish a common platform of understanding across Member States.

This manual has been sponsored by the AEEBC and written by a practising Building Surveyor and Construction Expert. The structure and content serve to guide those who are new to this professional area and to provide examples and case studies of good practice for existing practitioners. The manual reflects the different forms of construction prevailing between north and south European States, and deals with the application of principles, concepts and methodologies irrespective of business cultural differences, traditional industry approaches and procurement practices. The cases used for illustration are drawn from public and private sectors and from a variety of property types and uses.

Chapter one covers building life cycle and maintenance definitions and the importance of establishing strategy and policy in the context of property asset management and business planning. The continual changing nature of building standards and user expectations are addressed, together with the maintenance systems and techniques which have evolved to meet the challenges for caring for and renovating property.
Although definitions of building pathology differ between organisations, it is a subject which is principally concerned with defects and optimum remedial action. In chapter two entitled Maintenance Technology, management techniques focus on a typology of common building defects and a model to investigate the root causes which lie behind signs and symptoms and the identification of corrective measures. Apart from taking effective corrective action, emphasis is laid on advising owners on strategies to prevent the repetition of defects.

Planning and Finance deals with a fundamental tenet of maintenance management, which is to encourage the adoption of a planned approach to building maintenance rather than persisting with a reactive and unplanned policy. Identifying, prioritising, costing and funding maintenance are key components of planned maintenance. Chapter four also provides an introduction to measuring and managing performance in this context.

The central role of information technology in this maintenance management process is highlighted in chapter five. Matching information and output requirements with property asset management systems is examined, together with whole life and other techniques and methods to standardise data management. The development of software and mobile devices has both enabled and facilitated the wider adoption of a planned approach to property maintenance. Current and future web based tools are studied in this chapter.

The final chapter explores maintenance management interventions in meeting the challenges imposed by sustainable construction and the conservation of the built environment. Particular emphasis is placed on assessing measures to improve energy efficiency in buildings in order to reduce consumption, save money and reduce the carbon footprint.

Students and professionals who have read this manual will attain the following learning outcomes:

1. Understand the concepts, methods, techniques and systems which underpin building maintenance and the value of policy, strategy and plans
2. Appreciate that to keep the building fabric in a good condition and performing satisfactorily, requires a knowledge and understanding of defect failure mechanisms, investigative methods, and effective remedial and preventative strategies.
3. Awareness of the business case required to invest in a planned approach to building maintenance, and the application of performance management to maximise cost savings and provide better value for money.
4. Realise that effective maintenance planning and management needs to be supported by good information, an evidence base and by IT systems.

5. Understand the implications and challenges for building performance in achieving reductions in the environmental impact imposed by buildings.
CHAPTER 2

IMPORTANCE OF BUILDING MAINTENANCE

2.1 BUILDING LIFE CYCLE AND MAINTENANCE CONCEPTS

2.1.1 Maintenance Definitions

The building elements of an individual property will begin to naturally deteriorate in physical terms or performance upon completion of the construction. In addition to this natural aging process, unexpected physical and performance failure may occur, which we may describe as pathological decay. Consequently there is an immediate need for the owner and occupier to put in place a maintenance regime to prevent or mitigate the effects of any failures which may affect the functioning, use and value of the building. Theoretically it is then possible with an effective maintenance regime in place, to extend the physical life of any building almost indefinitely, subject to the load bearing structure of the building being intrinsically sound.

Individual buildings can be considered as assets and as a resource. Assets in the sense that the building has a capital value to the owner or developer who may just wish to sell it upon completion. Alternatively a building is clearly a resource to be used by occupiers in delivering services and as a means of production. Irrespective of whether or not the building is considered to be an asset and or a resource, it needs to be effectively and economically maintained in order to ensure that its value is not eroded and that it performs satisfactorily in a functional sense.

Numerous other factors come into play to influence the extent of the maintenance regime adopted for an individual building, including land and property value; funding sources; functional life and the standards and expectations of building users; maintenance and improvement costs, all
of which influence the physical, economic and functional life of the building. These influencing factors will be explored in this book.

To set the context for examining the management of building pathology and maintenance, it is as well to start with definitions of terms and commonly used. The table below provides standard definitions adopted in the professional field of building maintenance. The terminology may appear confusing with so many different forms of maintenance, but it does reflect in part the growing prominence of the subject during the past twenty years amongst professional institutions, industry, research groups, academics and government.

**Commonly accepted maintenance definitions**

**Building Pathology**
Building pathology is defined as the systematic treatment of building defects, its causes, its consequences and its remedies. The basic aim of Building Pathology is to understand the degradation processes, to define methods and tools in order to easily identify potential defects (at design stage, as well as in actual service), to devise solutions to reduce their effects and to avoid any unforeseen cost for repair or maintenance.

**Building Element**
A building element is a part of a building or structure with a distinct function, such as an external wall or roof. The sub-elements of a roof would include the structure, covering, insulation, and drainage.

**Condition based maintenance**
Preventive maintenance initiated as a result of knowledge of the condition of an item derived from routine or continuous monitoring.

**Corrective maintenance**
Maintenance carried out after a fault has occurred and intended to put an item into a state where it can perform a required function in a safe and efficient manner.

**Economic Life**
The estimated number of years until an item no longer represents the least expensive method of performing its function.

**Maintenance**
The combination of all technical and associated administrative actions intended to retain an item in, or restore it to, a state in which it can perform its required function.

**Maintenance Management**
The organisation of maintenance within an agreed policy.

**Maintenance Policy**
A written statement issued by, or on the authority of, the client and which is acceptable to the owner of the building.
Planned Maintenance
Maintenance organised and carried out with forethought, control and the use of records to a predetermined plan. (Note: preventative maintenance is always part of planned maintenance; corrective maintenance may not be).

Preventative maintenance
Maintenance carried out at predetermined intervals or corresponding to prescribed criteria and intended to reduce the probability of failure or the performance degradation of an item.

Reactive (Responsive maintenance)
Repairs carried out on an ad hoc basis as the need arises and which cannot be deferred for inclusion in planned maintenance programmes.

Scheduled maintenance
Preventative maintenance carried out in accordance with an established schedule e.g. time interval, number of operations, mileage.

Sinking fund.
A sinking fund is money invested to provide future funds to cover the cost of capital expenses which may be forthcoming in the future or long term.

Implicit within any definition of maintenance is the concept of acceptable standards in the care of buildings. This concept raises various issues relating to who is responsible for financing the maintenance, when and why it may be required and to the question of building standards remaining acceptable through time.

Estates managers in different sectors have taken the industry standard definitions of maintenance and modified the terminology to reflect their individual circumstances. This practice has been pursued in the management of the state owned property estates in healthcare, schools, universities, defence, municipal (local) government and rented public housing. Various manuals and guidance on managing building maintenance issued by sector specific representative bodies, have sought to reflect the needs and challenges faced by their owners, building users, funders and statutory enforcing bodies.

In agreeing the terminology adopted in this field, one particular issue that has exercised practitioners, is that of the relationship between maintenance and improvement. It would appear to be logical to incorporate localised improvements in the definition of maintenance, such as replacing worn items with new and efficient elements. However, where the intention is to add facilities which were not previously present, - installing air conditioning for example where none had previously existed – then this should be defined as an improvement (Lee 2000).
Experience has demonstrated that neglect or shortage of funding within an organisation causes a maintenance backlog. If building elements begin to deteriorate as soon as the construction project is complete, then ideally owners and occupiers need to plan for future repairs and replacements and set up a sinking fund or maintenance programme and budget. Maintenance backlog is the term given to the situation where repairs and replacements do not keep pace with the deteriorating condition of a building or compliance with statutory regulation. The forward planning of maintenance requirements becomes critical where the physical building condition has deteriorated to the state where building services have to be closed down, or where the health and safety of occupants is put at risk. To forestall such situations from arising and for reasons of business efficiency generally, the forward planning of maintenance has become widely adopted as best practice in estates and facilities management.

Backlog maintenance can also be expressed as the cost to bring property estate assets which fall below a certain defined physical condition and/or statutory compliance level, up to an improved standard condition. A significant role for the maintenance team then, is to set an appropriate standard condition for the properties under management, provide advice on an investment programme to improve the condition of sub-standard assets and to maintain them to an agreed level. The maintenance planning process should also incorporate preventative action, using lifecycle forecasting techniques, to ensure that funding is in place at the right time to expend on assets likely to fall into backlog maintenance.

Risk assessment techniques can be applied to measure the likelihood and potential consequences of an undesirable event or potential failure occurring. A good illustration of this application of risk analysis to managing maintenance backlog can be found in the healthcare sector of a European member state (NHS Estates 2004). The consequences of not undertaking appropriate and necessary repairs and replacements in hospital buildings and medical facilities can include: increased risks to patients and to clinical activity, the lowering of staff morale and recruitment difficulties. Other consequences would include increased exposure to legal liabilities and an escalation of capital investment requirements due to accelerated deterioration.

The risk assessment technique applied in healthcare sector case uses a scoring system, to rank different risks in a matrix, defined by potential consequences and probability of failure. The risk matrix covers criteria under the headings of health and safety, environmental conditions, building operational
and engineering functions. The severity of ratings are ranked on a scale from insignificant to catastrophic, whilst the probability of failure is rated a low score if considered to be rare and high if it is judged to be almost certain. For example a high scoring and, therefore, high risk score might be awarded to finding a failing flat roof over an operating theatre, an unreliable boiler for space heating or air conditioning system for cooling.

Similar building condition, statutory compliance and functional suitability rating systems have been developed and applied in other sectors – public housing, schools, municipal buildings and universities – to measure backlog requirements and to forecast and plan for maintenance expenditure.

2.1.2 Life cycle costs and relationship with maintenance

Research has demonstrated that the costs incurred over the whole life of a building are considerably greater than the initial construction costs. This realisation has spawned the development of life cycle costing techniques and their application in obtaining best value for money in procurement, whereby the on-going revenue and resource costs of a project are assessed at design stage as well as the initial capital investment.

This principle of whole life costing is embodied in property asset management software, where all building element replacement cycles can be mapped for different property types and overlaid with information on day to day repairs, cyclical servicing, maintenance and management costs. Whilst the process of accurately predicting future costs and service quality is fraught with difficulties, it is surely better to plan for the future based upon the best information available at the time rather than not to plan at all.

The often quoted research which demonstrates the importance of whole life costing is published by the Royal Academy of Engineering in the USA. They found that the typical costs for owning a building are in the ratio of 1:5:200 where:

- 1 represents initial constructions costs
- 5 for maintenance costs
- 200 for building operating costs.

This ratio was subsequently challenged by a University of Reading team in 2004 who, on the basis of research data for three office buildings, suggested
that the ratio might be nearer 1:0.4:12 (Hughes, Ancell, Gruneberg and Hirst 2004). These and other studies, however, have demonstrated that clients who focus solely on driving down construction costs whilst ignoring maintenance and operating costs are unlikely to achieve best value over the medium to long term.

Underpinning lifecycle costing in part is the recognition that each building element has a standard minimum operational life. Indeed this is recognised in research undertaken by the Building Cost Information Service who publish typical, minimum and maximum life expectancy values for numerous common building elements.

All maintenance assessments, however, must recognise that any prediction based solely on the remaining life of an element or component rather than their current condition – as materials and systems can fail earlier or continue in service well beyond their predicted useful lives – can be misleading. The life expectancy of any building element will be highly dependent upon a good maintenance regime, where adherence to industry best practice and manufacturers’ recommendations should prolong the life to next replacement. Equally the individual design, construction, location, ground conditions and many other factors influence performance and life expectancy, which requires professional interpretation and judgement when assessing specific circumstances.

2.1.3 Maintenance Strategy and Policy

Every organisation with a strategic corporate business plan should have component section relating to real estate or property. The needs of individual businesses and organisations will dictate their requirements for acquiring premises, lease negotiations, adaptation and disposal of property. An integral part of the real estate strategy will be the property maintenance strategy and the policy and programme which underpin it.
Fig. 2.1. Relationship between maintenance programme and strategic plan

A building maintenance policy should comprise of a clear statement of the objectives and methods to be employed in keeping buildings fit for purpose and use, and in preserving their value as built assets. This policy statement should provide the framework upon which all building maintenance and management operations are based and ideally it should state the required life expectancy of these assets (RICS 2009).

The policy should lay down guidelines in the following areas: building maintenance standards, statutory obligations – particularly health and safety - budgetary control, use of contractors, directly employed labour, and the control and execution of maintenance and servicing operations. Maintenance work needs to be planned in terms of a timeframe and the maintenance policy should provide guidelines on the scope and extent of the maintenance programme.
Repairs and maintenance can be of central importance to a landlord’s business activity, which is why every organisation should operate within a strategic framework. In the public sector, landlords may be incentivised to deliver maintenance services to a prescribed level, because funding for a new development will be conditional upon having an acceptable property asset management strategy in place which will incorporate repairs and maintenance.

The case of a public rented housing organisation is used here to illustrate the defining principles of adopting a maintenance strategy and policy. For such an organisation, the business plan sets out the direction of the corporate body in the short to medium term, together with the resources required to achieve its objectives. The asset management strategy should link the organisation’s overall strategy to the development of effective repairs and maintenance policies and practices. The budget for repairs and maintenance will then need to be affordable within the context of the organisation’s overall business plan.

To develop this public housing example further, the property asset management strategy will address policy issues such as: demand for housing; the condition of the housing estate; standards required and customer needs; investments, disposals and acquisitions; economic and environmental sustainability. Armed with the knowledge of what investment is needed in their properties, the organisation can then determine the balance of options available between demolition, disposal, refurbishment, maintenance and repair levels, in order to meet their customers’ current and future needs and the overall objectives of the business.

Policy decisions on procuring and delivering building repairs within this framework will be required in areas such as:

- Service level agreements e.g. defining an urgent response
- Whether to outsource a repair service or undertake it in-house
- Investment in call centres and customer care
- Defining performance measures
- Reviewing organisational structures, processes and systems
2.1.4 Relationship between maintenance management functions

Managing building maintenance is a process which can be broadly summarised as comprising: the compiling of a maintenance plan and programme, implementation of this plan and then measuring its performance. This process can be further broken down into discrete stages covering the following:

- Collection and collation of information on physical building condition
- Prioritising and costing of repairs and maintenance
- Tendering and contract management
- Project and programme management

The building surveyor/construction expert is, therefore, required to have skills and expertise in a number of areas including: information management, resource planning, budgeting, contract management, project management and in the supervision of a directly employed maintenance and repair service. In one model of maintenance management, the functions can be broken down into: types of maintenance; timing (cyclical or single occurrences); reason for the maintenance and the form of maintenance activity.

The work of the building surveyor/construction expert encompasses the whole range of building services, structure and fabric, dependent on the size and complexity of the properties held by a business or organisation. The need for maintenance of these buildings will be driven by predetermined standards of reliability performance; financial, productivity or safety requirements, subject to the demands of the business. The type of maintenance activity undertaken could be planned and programmed or corrective, and the maintenance tasks will range from a monitoring procedure to executing a repair, replacement or refurbishment. These different but complementary maintenance functions need to be managed to varying degrees in each and every business and organisation.

Maintenance management functions differ in sophistication between the needs and resources of say a small regional business and a large national corporation. If we compared how maintenance is managed between a major national banking group and a large chain of low value merchandise retailers, we would expect to see higher standards of business and customer expectation in the former as a general rule, reflected in a more sophisticated and professional approach to managing building maintenance. Whilst both these businesses are required
to meet statutory and contractual (leasehold) obligations and to act in a socially responsible manner, the bank will be more likely to choose to practice best practice maintenance management. This would include managing risk proactively with planned inspections and assessments, together with a greater emphasis on planned and preventative maintenance management.

2.2 ASSET MANAGEMENT AND FACILITIES

2.2.1 Asset management and business plans

Property asset management is the activity that ensures that the land and built asset base makes the maximum possible contribution to achieving the goals and objectives of a business or organisation. Asset management planning then is a business process with the underlying purpose of achieving the best use of property assets and of minimising the opportunity costs of resources tied up in land and buildings. Businesses, public services and organisations are constantly faced with new challenges and opportunities - which are either generated externally or internally – and they consequently need to plan to accommodate the resulting changes.

The value of property as an asset and as a resource to an individual business or service varies, but the real estate or asset management strategy is often one of the key considerations in formulating a business plan. A clear understanding of the needs of the property estate is a necessary pre-condition to confidently drawing up an asset management strategy.

The key potential benefits in preparing and delivering an asset management plan are:

- Improved information on property assets
- Increased awareness of costs
- Provides a platform for achieving a sustainable asset base
- Longer planning horizon
- Supporting the business case for seeking funding
- The release of capital for re-investment or debt redemption
- Reduced running costs
- Better customer service through improved accommodation and the co-location of services
- Improved property condition and utilisation
- Improved productivity, changes in corporate culture and facilitation of corporate change.

The asset management plan draws its aims from the corporate plan and addresses potential shortfalls in space, surplus space, unsuitable or inappropriate space; and the preparation process includes the appraisal of opportunities for development, rationalisation and reconfiguration of the estate. An integral part of the concept of property asset management adopted here, is that of having an effective facilities management regime in place which supports the core business objectives of the organisation. Facilities management in this context includes, energy procurement, telecoms, security, cleaning, waste disposal and office services. The interrelated aims of asset management are:

- To safeguard the long term interests of property assets
- To meet building users’ expectations and requirements
- To fulfil the safety and statutory requirements associated with an asset
- To formulate a replacement and up-grading policy for property assets.

### 2.2.2 Maintenance and asset management plans

The process of preparing an asset management plan for an estate would comprise assessing the physical condition of the building fabric and services, internal spaces and external areas; appraising functional suitability, space utilisation and user satisfaction; reviewing property values, sales and rents; and addressing the long term sustainable use of assets.

Good examples of asset management plans should include a strategy for dealing with acquisitions, disposals, lease negotiation, asset maintenance and performance management. Building maintenance management should in turn be driven by aiming to advance the business objectives of the occupier, such as: delivering efficient and effective services; ensuring the health and wellbeing of occupants; enhancing the productivity of users; ensuring that premises remain fit for purpose and preserving the value of built assets.
Real estate which is held for investment purposes might be expected to make different demands on maintenance management to property which is held for principally for occupation and use, although the two are not necessarily incompatible. For example it would be in an owner’s interests to improve the lettableity of premises by maintaining accommodation to a very good standard, which might also be expected to enhance the value of the property. Notwithstanding this there are some circumstances in city centres where high land and property values question the need for a rigorous planned maintenance regime, when redevelopment will realise the value of the capital asset irrespective of the condition of a building. Equally there are circumstances where the increasing maintenance costs of an aging asset become uneconomic to sustain in relation to the residual value of that property.

There has been a growing realisation, particularly it might be argued in the state sector and in large corporations, that property assets are an integral part of business planning. For a business to operate efficiently then the property it occupies needs to function effectively and this requires effective maintenance strategies and policies.

2.2.3 Surveys for asset management plans

Balancing the availability of limited resources with the changing needs of a business, the demands of statutory regulation and keeping assets in a state of good repair are just some of the many challenges building surveyor/construction experts face. Having a clear understanding of existing physical condition of properties is crucial to targeting and prioritising expenditure, in order to achieve best value in meeting these organisational needs.

Building condition surveys are the preferred management technique for assessing the physical condition of premises comprehensively, for gauging compliance with current statute, and for evaluating energy efficiency, space utilisation and functional suitability. The output is delivered in a database which can be updated for strategic planning purposes and the information collected is often of great value for operational maintenance purposes.

The output from this type of survey provides data to enable repairs, maintenance and improvement work to be identified, costed, prioritised and
planned. The information provided by the survey enables informed decisions to be made and thus resources can be targeted to where they are most needed.

The overlapping and complementary provisions of different statutes and regulations provide an opportunity for managers to focus their assessment and identify expenditure priorities. The data collated from these comprehensive surveys also provides the basis upon which to appreciate the interrelationships between maintenance and building adaptation.

Multi-faceted building condition surveys would typically encompass audits and assessments of the following:

- Building structural stability
- Physical condition of building fabric, finishes, and services
- Accessibility, particularly for the disabled
- Risk assessments for fire safety, water and general hygiene
- Risk to health, safety and welfare, including hazardous materials
- Updating of floor plans
- Reinstatement costs for insurance valuation
- Energy efficiency and environment
- Appraisals for refurbishment or improvement
- Functional suitability, space utilisation and fitness for purpose
- Preparation of asset register of mechanical and electrical plant and equipment

Project managing these complex surveys for large and extensive built estates, in order to deliver good quality information for maintenance planning purposes, will involve the following key stages:

- Initial planning and co-ordination, including securing funding
- Reviewing data needs
- Developing the survey brief
- Reviewing commissioning options
- Specification development
- Procurement of contractors
- Implementation including quality control and progress monitoring
- Data analysis, reporting and taking ownership of the survey database.
2.3 STANDARDS AND EXPECTATIONS

2.3.1 Setting acceptable standards

The physical condition of buildings has a direct impact on the building users, which in turn affects the success of a business or the delivery of a service operating from the premises. But to what standard should we seek to maintain the condition of buildings? The answer to this question ultimately determines the scope and content of the building surveyor/construction experts’ workload. Building owners and managers are faced with the dilemma which is summarised in the chart below, whereby standards decline over time as buildings age whilst user expectations and requirements simultaneously increase, resulting in functional obsolescence.

![Graph showing standard, expectations & regulations, and deterioration driving maintenance over time.](image)

**Fig. 2.2. Functional obsolescence in buildings**

Different approaches can be adopted to defining maintenance standards. From an owner’s perspective there may be no financial incentive to do more than the statutory minimum and to comply with existing leasehold terms. This might be the case for an owner with property in a shopping street which is no longer fashionable and which consequently becomes a less lucrative location. An occupier on the other hand would generally seek to establish higher
standards of maintenance to support the business objectives of their organisation. For example damaged internal surfaces in an office block due to cracking or dampness would generally be intolerable to an occupier, as this would have a detrimental effect on employee morale and customer perception and could possibly result in considerable future consequential damage to the structure and building services.

As building surveyor/construction expert know only too well, there is inevitably a disparity between the actual maintenance needs of a building and the funding and resources available to service that need. This disparity is a key justification for a planned approach to maintenance. Asset management and maintenance planning has now become firmly embedded in the culture of the public sector and in many corporations, where identifying, quantifying and managing future maintenance needs are routinely practised. Where there is a commercial lease in place, then theoretically there is the discipline of a having an imposed maintenance plan in place through the liabilities represented in the repairing and other covenants of the lease.

### 2.3.2 Statutory compliance

A distinction should be drawn between what might be called desirable and essential maintenance standards. Desirable standards would include decoration and internal comfort conditions while essential maintenance includes compliance with statutory or regulatory controls, which aim to achieve minimum acceptable building standards through the enforcement of legal codes of practice.

The building surveyor/construction expert will be actively involved in implementing national and local Town Planning and Building Codes (Regulations) which apply to new construction, building extensions and alterations. These standards primarily relate to structural stability, health and safety (sanitation and fire safety) and environmental requirements and they increasingly seek to address sustainability in construction. Statutory codes and regulations change over time to meet the higher standards required in areas such as energy efficiency, fire safety and structural stability, but they are generally not enforced retrospectively. Consequently the opportunity is often taken during reinvestment or major maintenance programmes to bring properties up to current statutory standards where it is technically feasible to do so.
Once new buildings are occupied then a range of other statutory standards may apply, relating to their use as workplaces, residences or as publically accessible premises. Risk based assessments typically relating to compliance with health, safety and welfare standards would apply (see example below). Landlords and occupiers may have a statutory duty of care and liability towards users, visitors and neighbours whether invited or present as trespassers.

Examples of statutory regulations relating to workplaces, educational, leisure, healthcare and other types of premises:

- Harmful and hazardous substances and building materials e.g. radon and asbestos
- Electrical and gas safety
- Fire safety
- Water hygiene and safety
- First aid
- Lifts and hoists
- Working safely
- Plant and equipment used at work
- Lighting, ventilation and thermal comfort
- Sanitary facilities
- Facilities for rest, meals, washing and clothing
- Accessibility for disabled

A further distinction should be drawn between statutory standards which are enforceable by law and those standards which are recommended as best practice either in guidance which may accompany a statute or emanate from professional practice. An example of the latter might be the installation of emergency lighting on general health and safety grounds as a fire precaution measure.

There may also be quasi-statutory standards promoted by national government, where a benchmark standard is established for publically funded improvements to healthcare, housing or educational premises. In these cases achieving the minimum standards set usually determines the level of funding provided.

Finally there are also many aspects of building performance which are unrelated to statutory and regulatory standards, examples of which include the internal and external appearance and finishes of premises and the overall physical condition of the building fabric. The condition of external walls and roofs in a building may have suffered from neglect and incurred damage due to rain
penetration, but statutory enforcement action would only commence where the consequences of defects jeopardise health, safety and welfare.

Table 2.1. Statutory regulation and building defects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Statutory enforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural stability</td>
<td>Yes</td>
</tr>
<tr>
<td>Disruption to users</td>
<td>No</td>
</tr>
<tr>
<td>Hazards leading to loss of service or building use</td>
<td>Possibly</td>
</tr>
<tr>
<td>Unsightly</td>
<td>No</td>
</tr>
<tr>
<td>Uncomfortable</td>
<td>No</td>
</tr>
<tr>
<td>Fitness for purpose</td>
<td>No</td>
</tr>
<tr>
<td>Asset value</td>
<td>No</td>
</tr>
</tbody>
</table>

2.3.3 Functional suitability and use of space

A further aspect of building standards and one which relates to the expectations of all stakeholders is that of functional suitability, quality and use of space. Is the building generally fit for purpose and how does this impact on maintenance management?

Suitability and fitness relate to how well premises meet the needs and expectations of users. In the case of schools and colleges for example, how appropriate and sufficient are the premises for raising the standards of education. The size, shape, layout, environment and location of rooms and spaces, and quality of fittings and infrastructure can directly influence teaching methods, learning abilities, morale and behaviour.

It is common practice in sectors such as education and healthcare to adopt minimum space standards which provide a benchmark for measuring building performance. Managing the need, layout and use of space in large institutions and companies is an on-going process, which highlights opportunities for the rationalisation and remodelling of space. This in turn impacts on the timing, extent and funding of maintenance. Remodelling internal space for example will include altering the layout of building services and floor, wall and ceiling
finishes. Non urgent maintenance work on these elements could be deferred until the improvement work commences.

2.4 MAINTENANCE SYSTEMS

2.4.1 Risk assessment and maintenance management

Risk assessment is an integral and essential part of maintenance management, which recognises the possibility that unexpected events may affect the intended objectives of a project or programme. The systematic identification and management of risks addresses this and through analysis, provides an assessment of the likelihood of project success. The risk management process helps to identify potential unacceptable costs increases, time delays or shortfalls in performance and by recognising what action can be taken to influence the causes and/or consequences of the risks, seeks to maintain the balance between customer expectations and the preferred solution.

Every business and service provider will occupy business critical buildings and facilities. Organisations need to identify and control the risks which could lead to the loss of a building or facility, and the management measures adopted will influence the design, installation and maintenance of building services for example. The risks posed to business are many and varied and can include: flooding, fire, security, water safety, the presence of hazardous building materials and the failure of critical building services. Whilst the risk to life will assume the highest priority, financial loss and interruption to operations and service provision will be extremely important.

Managing risk also applies to ensuring compliance with statutory regulation and avoiding criminal or civil action. Enforcement action or litigation can be disruptive, costly and ultimately damaging to a business and the process of managing risk will draw upon techniques of avoidance, prevention, contingency planning, transfer and retention of residual risk.

Managing the risks identified for each organisation will influence the maintenance systems adopted. Critical business functions rely upon the integrity of the building envelope and the availability of building services
and how resilient they are. This is very well illustrated by IT and communications equipment and systems for all businesses, but particularly for those which are office based. The results of risk assessments should drive the business to adopting a more planned approach to managing maintenance. All owners and occupiers will want to keep control of building maintenance costs and manage the inherent risks through a planning regime.

2.4.2 Reactive vs. planned maintenance

Professional best practice suggests that there are financial and efficiency savings to be made and benefits to be gained in terms of value for money over the medium term, in moving from a position of predominantly unplanned expenditure to a budget driven by planned maintenance. UK Government auditors set a target ratio of 75:25 planned to unplanned annual maintenance expenditure which public sector organisations should aspire to achieve. In setting out the business case for moving to a more planned maintenance system, a manager will need to demonstrate evidence of efficiency savings from the investment required to implement a planned maintenance regime. A strategy based on planned inspections, forward planning of budgets, exacting cost control and regular reviews of maintenance procurement would underpin such a business case.

Unplanned maintenance is characterised by the carrying out of tasks in reaction to a situation, possibly resulting in prolonged breakdowns of building services or the need to urgently repair damage which has arisen as a consequence of neglect. Unplanned tasks may result in uneconomic, inappropriate, inadequate and costly work. Planned maintenance on the other hand is controlled and follows a recognisable procedure. A maintenance plan for building services for instance may comprise a mix of methods: preventative, corrective, condition based, opportunistic or be predetermined by scheduling requirements in advance (Chartered Institution of Building Services Engineers CIBSE 2008).

One of the objectives of planning a maintenance programme is to ensure that all building elements are maintained to a pre-defined standard and that any incipient defects are thoroughly investigated and rectified. An organisation would be expected to have a five, ten or even longer term strategic maintenance programme, together with a more detailed, costed, rolling annual implementation programme.
Managing and forward planning of maintenance is largely concerned with predicting and preventing failures before they lead to undesirable outcomes. This approach is reliant upon identifying maintenance needs in advance so that the appropriate remedial action – servicing, repairing or replacement action – can be taken efficiently and cost effectively.

The basis of preventative maintenance then is to take action before the failure can occur wherever reasonably possible. This could take the form of repairing initial surface cracking in reinforced concrete columns and beams before the onset of carbonation and consequent corrosion of the steel and spalling of the concrete; or it could be re-pointing and repairing facing brickwork to stop or reduce rainwater ingress, which in turn creates damp conditions within the structure resulting in fungal growth, rot and the loss of structural strength in embedded timbers.

2.4.3 Identifying maintenance needs

Planning and managing maintenance is underpinned by the process of identifying need. For a given property estate, maintenance needs should be identified by the following methods as a minimum form of practice:

- Regular building condition/statutory compliance surveys
- Existing planned maintenance programme
- Faults and repairs notified by the building users
- Feedback from servicing, repairs and improvement works
- Statutory regulations and lease repairing covenants

A major source of information for assessing maintenance need is the building condition/statutory compliance survey which is commissioned at five or ten year intervals. The large volume of survey information gathered for an estate during this process is captured for analysis in a database. Typical building condition issues addressed during the survey include:

- Physical state and need for maintenance
- State of disrepair of each element
- Compliance with health and safety and other statutory requirements

The condition survey comprises an organised, systematic, comprehensive visual inspection of all building elements. Repairs and replacements are identified,
quantified, costed, prioritised and scheduled on the basis of condition, state of repair and ascertained remaining life expectancy of individual building elements. Typically the maintenance work identified will be classified into either: major replacements; unscheduled replacements, repair and maintenance; minor replacement, repairs and maintenance; redecoration or refurbishment and adaptation.

An appraisal of the importance of building assets to an organisation should include criteria such as corporate image, together with an appraisal of the consequences of failure in building systems (BISRIA 2000). Where building condition surveys are undertaken in order to inform the asset management plan, the relative importance of the state of repair of building elements contained in each property, when measured against the desired maintenance standards, can be conveniently represented by a ranking system. There are various systems in common use and they all relate to the appropriate maintenance standards adopted within each organisation. A typical ranking system for the condition of building elements would comprise the following categories: critical, essential, important and desirable.

One such condition ranking or coding system in common use has four categories, ranging from good, satisfactory, poor to bad. When a building element or component is in a good condition it is by definition, performing as intended and operating efficiently. The parameters for each individual building element – windows, roof covering, electrical installation – are either pre-defined or the standard is generally understood. A satisfactory condition would mean the building element is performing as intended but showing minor deterioration; poor is defined as showing major defects and/or not operating as intended; bad would constitute life expired and/or in serious risk of imminent failure.

The maintenance policy of the business or organisation should specify the minimum standard or desired performance level to which a particular asset or building element should be maintained. Thus if the set standards cannot be sustained then remedial action would be flagged to restore the asset or building element to the agreed acceptable standard.
2.4.4 Prioritising maintenance works

Having identified maintenance needs, building surveyors/construction experts then have to prioritise requirements in-order to best allocate resources in accordance with the broader objectives and plans set by the business or organisation.

The appraisal of building condition has to address the question of when maintenance work needs to be carried out. During this process the building surveyor/construction expert has a duty to inform the organisation of the consequences of deferring expenditure on particular repairs and maintenance. The relative importance attached to individual building elements is represented during a condition survey by a ranking system described above which forms part of the survey methodology.

Various methods are used for prioritising maintenance works in a methodical and systematic way. Within each methodology the priorities are defined to ensure consistency can be maintained across the building portfolio and understood by all stakeholders. Prioritising methods could be based on one of the following approaches:

- The urgency of remedial action and consequences of failure (see table below)
- Repairing priorities e.g. neglect that may affect current rental income
- Action and effect e.g. failure to rectify a defect will result in rapid consequential damage and subsequent cost, or constitute a nuisance to users of a building
- Attribute based e.g. building status, physical condition, importance of usage, effects on users, cost implications or effects on service provision.

Different methodologies for prioritising maintenance works will suit different businesses and organisations. Even where they are not explicitly documented, the smallest organisation will be keen to time their maintenance actions to avoid or mitigate hazardous conditions (high risk to life and/or property, non-compliance with the law, dangerous conditions (faulty conditions or operational problems threatening serious consequence), more relatively minor risks to health and safety and/or property or contravention of good practice standards. Priority ranking methods provide added value when the action for each category level has a maximum stipulated time frame e.g. urgent means “within a week”; essential “within two years”.

35
Table 2.2. Coding system for building condition surveys

<table>
<thead>
<tr>
<th>Priority level</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority 1</td>
<td>Unavoidable: deferring would breach statutory regulations, health &amp; safety or be significantly detrimental and disruptive to building users</td>
</tr>
<tr>
<td>Priority 2</td>
<td>Essential: deferring would seriously increase risk of consequential damage</td>
</tr>
<tr>
<td>Priority 3</td>
<td>Urgent: desirable to maintain value, functionality and usefulness</td>
</tr>
<tr>
<td>Priority 4</td>
<td>Desirable: to maintain standards or for improved efficiency or best value</td>
</tr>
</tbody>
</table>

Deferring building maintenance can cost time and money. Property asset management systems are now considered to be essential tools to enable management action to be directed, expenditure to be prioritised and performance to be monitored. Individual items of maintenance work can be undertaken more cost effectively as a single minor works contract rather than on a day to day repair basis; similarly backlog repairs can be executed within refurbishment and planned maintenance projects.

2.4.5 Delivering maintenance

The effective and efficient delivery of maintenance is dependent upon good management structures and processes being in place, as well as the procurement strategy chosen. The maintenance management function is performed by building surveyors/construction experts, property or facility managers, plant engineers, premises staff or by others, according to the size, turnover and type of organisation or business.

There are a variety of procurement options available to organisations in delivering repairs and maintenance. Each option will have advantages and disadvantages to suit particular circumstances. Standard forms of contract and business models have evolved in support of all these available options.

Repairs and maintenance can be delivered either by directly employed labour, outsourced to contractors or by a combination of both. More innovative
procurement models have evolved over recent years through partnership working between the client and private contractors and suppliers.

Partnership arrangements with contractors may include open book accounting, co-location of workplaces and shared risk. This latter option aims to encourage honest and open relationships, but it can be argued that it is a management intensive relationship, that benefits can take time to materialise and that long term partnerships could be uncompetitive in the marketplace.

National and regional procurement consortia can benefit individual organisations and building owners by providing opportunities to gain value for money through supplier discounts on volume purchases, rationalisation of supply chains, standardisation of component use and they can also influence product quality and development. Control over the supply chain is the rationale behind collective procurement and partnership working in general. Recent financial constraints in the state sector have driven more organisations to purchase maintenance collectively and in partnership with others to drive costs down.
CHAPTER 3

MAINTENANCE TECHNOLOGY

3.1 MECHANISMS OF DECAY, FAILURE AND DETERIORATION

A building defect can be defined as an imperfection, deficiency or fault in a building element, which adversely affects its functional performance or appearance. It is essential when specifying remedial and repair work that the root causes and not the symptoms of a defect are treated to ensure a long lasting fix. Knowledge of the underlying mechanisms of failure and deterioration is a pre-requisite to adopting a management process to investigate, diagnose and specify remedial action. Some building defects arise from the process of natural aging, weathering and normal use, but many result from premature failure, due amongst other factors to faulty design or specification, poor construction or lack of maintenance. In isolation, a building defect can be easy to quantify, diagnose and remedy. However, certain symptoms result from a combination of defects that can frustrate normal lines of enquiry and investigation. Sometimes complex causes may be present which frustrate an investigator’s attempts to resolve what at first glance might have seemed to be a straightforward issue. Complex investigations can arise in circumstances such as the following:

- Incorrect materials specified and/or inappropriately detailed
- Inappropriately detailed but correct materials
- Incorrect materials assembled or used
- Inappropriate design conditions of loading or exposure used in making calculations or predictions of performance
3.1.1 Typology of common building defects

A classification of common defects proposed by Addleston (1989) distinguishes between the following types: dampness and condensation; movement and cracking; subsidence and settlement; loss of adhesion and corrosion and decay. These five broad categories in turn can be further broken down by type and cause:-

1) Dampness and condensation
   - Condensation – surface and interstitial
   - Entrapped construction moisture
   - Rain penetration
   - Rising damp from the ground and surface water
   - Leaking pipes and storage tanks
   - Spillage from occupants equipment
   - Contaminating hygroscopic salts

2) Movement and cracking
   - Thermal movement (reversible and irreversible)
   - Moisture movement (reversible and irreversible)
   - Deflection of structural members
   - Chemical reactions e.g. corrosion, carbonation and sulphate attack

3) Subsidence and settlement
   - Soil and ground support
   - Water content and ground conditions
   - Changes in ground support
   - Changes in loading imposed on ground support

4) Loss of adhesion (in mortar, plaster, render, sealants, tiles and painted finishes)
   - Poor bond/inadequate background preparation
   - Differential movement
   - Degradation of material

5) Corrosion and decay
   - Direct oxidation/electro chemical
   - Insufficient protection
   - Fungal attack
• Insect attack
• Plant growth

The foregoing classification largely relates to the building structure, fabric and architectural finishes. The relative importance of the defect types varies between country according to traditional forms of construction and the effects of climate. In northern European countries load bearing masonry and timber members are commonly adopted for low rise residential construction, whilst in southern Europe cast reinforced concrete is the preferred form of building.

Categorising common failures and defects in building services is more problematic, given the large range and types of mechanical and electrical plant and equipment in use. One attempt at categorising common failures is as follows:

• Physical deterioration
• Inappropriate or inadequate systems
• Excessive temperatures in electrical installations
• Problems adversely affecting system performance
• Abuse by building users
• Redundant installations
• Inadequate access for maintenance and servicing
• Incorrect system operation or maintenance
• Statutory non-compliance

The agents or root causes that give rise to the different types of defect, failure and deterioration are many and varied. To understand what causes the symptoms that present themselves in buildings requires a thorough knowledge and understanding of how these agents and mechanisms interact. Agents can be grouped into those which can be defined as mechanical, electromagnetic, thermal, chemical, biological or derived from building users. Examples of the agents and mechanisms which can be grouped in this typology are:

Mechanical
• Dynamic wind load
• Ground pressure

Electromagnetic
• Solar radiation
• Ultraviolet radiation
Infrared radiation

Thermal
- Conduction, convection and radiation
- Expansion and contraction

Chemical
- Electrolytic action
- Action of water on thermal insulating properties
- Oxidation
- Sulphate attack

Biological
- Acidic and corrosive metabolic properties
- Vermin damage
- Plant growth

Building User
- Accidental misuse
- Deliberate vandalism

The management of building pathology as underpinned by a knowledge of these failure mechanisms and agents, acting in combination and upon building materials in different ways, causing a range of types of defects and failures to manifest themselves. Many defects are predictable in that experience demonstrates that, given compliance with a recommended maintenance regime, the performance of a given material or building element will nevertheless gradually deteriorate over its anticipated life. Similarly, experience demonstrates that if for instance rainwater is allowed to penetrate the building fabric because of ineffective or insufficient maintenance, then there will almost certainly be consequential damage to the internal structure and architectural finishes, that will require remedial work at a future time.

Unexpected defects arise for a number of reasons. As building materials and construction techniques evolve, failures can occur due to factors such as:
- Inappropriate use of a material
- Juxtaposition of incompatible materials
- Lack of understanding of basic science and technology
- Inadequate design and specification
- Poor manufacture
Formulating strategies to prevent failure from arising in building elements and/or to mitigate their effects relies upon a thorough understanding of the causes of failure in buildings in use and learning from the unintentional mistakes committed. Whilst there is a constant need and desire to innovate in design to meet the challenges of sustainable construction and to build efficiently and economically, lessons have to been learned to avoid the repetition of failure. This relies upon a continual process of education and feedback from building surveyors/construction experts to existing designers, constructors and to students and new entrants to the industry.

The feedback process must highlight the importance of ensuring that initial design and specification is soundly based, the construction process incorporates rigorous quality control and that a maintenance regime is implemented based on keeping the building and services in a good state of repair. Involving facilities managers at the design stage occurs too infrequently and consequently, straightforward issues such as ease of physical access to building elements to undertake inspection, maintenance and servicing are ignored or insufficiently considered.

Ensuring a low maintenance building is handed over satisfactorily, relies amongst many other factors, upon having a design undertaken according to best practice, competent monitoring of construction quality and good building records and manuals being in place.

3.1.2 Survey, investigation and diagnosis

Building surveyors and construction experts carry out different types of inspection and survey to meet particular requirements. They may for example be instructed to undertake a property pre-acquisition or due diligence survey and valuation, a building condition appraisal to prepare a maintenance programme, a measured survey in order to prepare plans, or a schedule of condition to protect an owner’s interests where adjoining construction work is due to commence.

During the life of the building it remains common practice that clients, surveyors and facility managers pass the risks on to contractors or specialist
companies in diagnosing defects and using their own propriety or preferred repair methods. This procurement route can often result in excessive or inappropriate work being carried out, whilst fundamental contributory causes of defects are often ignored in the process. Similarly, inexperienced small contractors are frequently called upon to establish the root causes of building defects, misdiagnosis occurs and inappropriate and often ineffective remedial work is then carried out.

An inspection commissioned to investigate a defect and to report on remedial work demands a particular set of survey skills and methodology. The investigative process can be illustrated as follows:

![Fig. 3.1. Simplified process map for defect investigation](image)

The simplified process shown in this chart adopts a forensic approach to investigating and establishing the corrective action for a defective building element. The surface symptoms presented to the building surveyor/construction expert are the starting point in this process; all potential causes and sources of defects are identified and eventually the diagnosed cause(s) is pinpointed by a process of testing and elimination. Following the implementation of recommended remedial action, best practice then suggests a period of evaluation and feedback.
Undertaking an investigation calls for a thorough and systematic approach to addressing the problem. Surveyors require a mix of technical and softer competencies and attributes. The former skill set includes a knowledge and understanding of building technology, construction and surveying; the latter softer attributes refer to fitness, pragmatism, self-reliance, resourcefulness and diplomacy.

The investigative process commences with the client instructing the surveyor in writing and confirming the scope of the survey, fees, insurance cover, the extent of opening up and making good, access into and around the premises. Preparation for the investigative survey may include a prior desktop study, information gathering and arranging logistics (see table below: Preparing a Survey Plan).

Table. 3.1. Plan for survey preparation

<table>
<thead>
<tr>
<th>Scope of survey and investigation</th>
<th>Desktop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methodology or procedure</td>
<td>Access arrangements for working at height internally and externally.</td>
</tr>
<tr>
<td></td>
<td>Inspection locations</td>
</tr>
<tr>
<td></td>
<td>Sample locations to be opened up.</td>
</tr>
<tr>
<td></td>
<td>Equipment and tools</td>
</tr>
<tr>
<td></td>
<td>Data recording</td>
</tr>
<tr>
<td>Personnel and safety issues</td>
<td>Health and safety information for the building.</td>
</tr>
<tr>
<td></td>
<td>Harmful and hazardous materials register e.g. asbestos</td>
</tr>
<tr>
<td>Report format</td>
<td>Structure and content</td>
</tr>
<tr>
<td></td>
<td>How data will be presented</td>
</tr>
<tr>
<td>How data might be stored, accessed and updated</td>
<td>Database and spreadsheets</td>
</tr>
<tr>
<td>Use of photographs, video records and plans</td>
<td></td>
</tr>
</tbody>
</table>

Depending upon the extent and scope of the investigation, a checklist for this stage of the process may include:

- Assembling a team e.g. engineers; testing laboratory; drainage or concrete core testing specialists
- Hiring equipment e.g. scissor lifts, hydraulic lift, scaffold, calcium carbide kit
• Destructive and non-destructive testing equipment e.g. covermeter; thermographic camera
• Previous reports; as built plans, sections and specifications; maintenance and operation manuals
• Tools e.g. laser distance meters, calliper gauge, electrical resistance moisture meters, endoscope, torch, penetration probe
• Health and safety risk assessments

An investigation of a failure in a large individual building or of a repetitive defect across a number of properties, may take the form of an extended investigation, to be executed in two stages. A preliminary inspection is initially planned, with some limited testing in order to assess the nature and scale of the problem and to plan a subsequent more detailed investigation. If we take the example of reinforced concrete members in a structural frame which are showing cracks, spalling and rust staining, the investigation will consider factors such as low cover to the steel, permeable concrete and chloride levels. With this two stage approach the preliminary inspection should include a visual inspection; testing samples for depth of cover and carbonation; and taking samples for laboratory analysis to determine chloride and cement content. The emphasis is on collecting sufficient information to enable a programme to be drawn up for the second detailed inspection and testing stage, when the full extent of the defects will be identified and quantified.

The preparatory stage involves preparing a health and safety risk assessment. Surveying safely requires the anticipation and identification of hazards affecting the survey team and building users before visiting the property and during the visit. Safety issues to be addressed will include: lone working; site conditions; activities and users at the premises; working a height; environmental conditions; dangers posed by live and unsecured services; hazardous materials and the provision of power and light.

With all the preparatory tasks completed, the survey team set about following the methodology planned in consultation with the building owner and occupants. The forensic approach to the defect investigation requires the methodical collecting and recording of evidence. The investigation follows an iterative process whereby hypotheses as to the likely causes of a defect are considered, analysed and tested in turn. A golden rule to be adhered to is that the surveyor must not jump to conclusions. The source of rainwater ingress below a large and complex roof may be some considerable distance from the symptoms which present as dampness on ceiling finishes, if indeed the source has been narrowed down to rainwater. Only painstaking testing with
the use of colour dyes, moisture detection instruments and other specialist equipment will help pinpoint the rainwater entry point.

A variety of building diagnostic techniques are applied in the collection and analysis of information on site. One classification of techniques distinguishes between visual survey techniques, verbal enquiry methods and verification techniques.

- **Visual survey techniques**
  - **Access problems**
    - Height e.g. cradles, gondolas, abseil
    - Depth
    - Proximity
    - Openings
  - **Observation methods**
    - Surface e.g. binoculars, magnifying glass, mirrors
    - Subsurface – smoke tests, electrical resistance meter
    - Internal void – endoscope
    - Structure – cover meter
    - Alignment checks – spirit level, lasers, level and staff, plumb line, theodolite, compass
  - **Sensory and recording techniques**
    - Text – written notes, pro formas and check lists
    - Oral – tape
    - Aural – verbal enquiries
    - Visual – rainy day survey of rainwater discharge
    - Sensual – touch, taste, smell
    - Instrumental – camera, video, laser measures, screwdriver, penknife
    - Pictorial – sketches

- **Verbal enquiry methods**
  - Sources of information
  - On site – building managers, occupiers
  - Off site – on line
  - Reliability – allow for bias, misrepresentation, uncertainty
  - Lateral thinking – problem solving, intuition
Verification

- As built floor plans and sections
- Testing methods
  - Portable instruments
    - Non-destructive e.g. thermo hygrograph, dew point sensors
    - Partial destructive e.g. endoscope
  - Site tests e.g. calcium carbide
  - Laboratory analysis – materials testing, asbestos
- Monitoring procedures
  - Long term e.g. movement
  - Medium term e.g. crack displacement
  - Short term e.g. water penetration by use of dyes
- Exploratory opening up and making good

Each type of investigative inspection presents different challenges in the planning and execution of the survey. Working in occupied premises can demand a particularly detailed plan of action, whether they are residences, factories, schools, shopping centres, hotels or offices. Opening up the structure or fabric as part of the investigative process and then making good has to be well managed.

Recording the information collected on site requires forethought and the adoption of a methodical system. The requirement for this discipline is illustrated in the case study below.
Fig. 3.2. Case study – investigating dampness and condensation in high rise apartments

Two twenty three story apartment blocks were investigated to ascertain the cause of extensive dampness and to provide a remedial plan of action with cost estimates. The high rise blocks were constructed of a reinforced concrete frame, floors and pre-cast panels on external walls. The inspection plan provided for three building surveyors to arrange internal access to all apartments by appointment to record the symptoms of dampness evident and ascertain possible causes. Information on the location and extent of dampness internally had to be recorded by mapping damp patches in a way that corresponded to the relevant positions on external walls for each apartment. This was because unsealed joints between pre-cast wall panels and cracks in the face of panels were recorded externally as part of the diagnostic process to eliminate possible sources of dampness. All members of the team had to be thoroughly briefed to ensure consistent, accurate and complete observations and records were compiled. Information was recorded on sketches, plans, photographs, video and in a spreadsheet for subsequent analysis and reporting.

One of the essential objectives of the inspection was to assess the range or diversity of possible methods of treatment, together with technically feasible and cost effective repair methods. The level of detail recorded in an inspection of this type will vary from building to building. Where drawings are unavailable some dimensional measurements may be necessary to enable details to be prepared for estimating the cost of repair work.
A logical sequence must be followed in the investigation and evaluation to help avoid an incorrect diagnosis of the fault, which could lead to inappropriate repair work being undertaken. Surveyors and engineers with the relevant experience and competencies should be deployed to ensure surface signs of defects – crazing or shrinkage cracking of concrete or render – is not mistaken for structural failure, such as cracking, buckling, deflection or leaning in walls, floors, columns and beams.

The decision making process followed during an investigation should lead the surveyor at an early in the process, to distinguish between typical or common types and atypical or unusual defects. Where the surveyor encounters abnormal symptoms, then further investigative work may be necessary. The defect diagnosis process draws on the building surveyors’ experience, knowledge and skill in providing evidence based conclusions. During this entire process the clients’ expectations must be managed through good communication, as they may be called upon to provide further finance and additional time and assistance to conclude the investigation. It is inevitably the case that once access is made available for a close inspection of building elements and the construction is opened up, additional symptoms and effects are invariably encountered. This outcome should support the business case for securing adequate funds to thoroughly investigate defects, in order to establish the exact causes and accurately quantify and budget for appropriate and permanent remedial work.

As part of the investigative process, building surveyors/construction experts are required to be able to use instruments for testing and monitoring or to commission competent specialists. Testing methods fall broadly into two categories, non-destructive and destructive types. The former testing methods apply techniques to existing buildings and structures to obtain results from in-situ analysis of material with minimal damage. These methods are fast, reasonably reliable and may be used in conjunction with destructive tests to enable reliable correlation of values.

Methods used for investigating problems with reinforced concrete for example - which are illustrated in the table 3.2. – would reduce the number of cored samples required to be taken.
Table 3.2. Non-destructive methods for inspecting reinforced concrete

<table>
<thead>
<tr>
<th>Concrete Properties</th>
<th>NDT Methods</th>
<th>Other Possible NDT Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength</td>
<td>Penetration probe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rebound hammer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pullout methods</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ultrasonic pulse velocity</td>
<td></td>
</tr>
<tr>
<td>General quality &amp; uniformity</td>
<td>Penetration probe</td>
<td>Ultrasonic pulse echo</td>
</tr>
<tr>
<td></td>
<td>Rebound hammer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gamma radiography</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ultrasonic pulse velocity</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td></td>
<td>Radar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gamma radiography</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ultrasonic pulse echo</td>
</tr>
<tr>
<td>Stiffness</td>
<td>Ultrasonic pulse velocity</td>
<td>Proof loading (load deflection)</td>
</tr>
<tr>
<td>Density</td>
<td>Gamma radiography</td>
<td>Neutron density gauge</td>
</tr>
<tr>
<td></td>
<td>Ultrasonic pulse velocity</td>
<td></td>
</tr>
<tr>
<td>Rebar size &amp; location</td>
<td>Covermeter</td>
<td>X ray radiography</td>
</tr>
<tr>
<td></td>
<td>Gamma radiography</td>
<td>Ultrasonic pulse echo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Radar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thermography</td>
</tr>
<tr>
<td>Corrosion state of reinforcing steel</td>
<td>Electrical potential measurement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Concrete resistivity</td>
<td></td>
</tr>
<tr>
<td>Presence of subsurface voids</td>
<td>Acoustic impact</td>
<td>Thermal inspection</td>
</tr>
<tr>
<td></td>
<td>Gamma radiography</td>
<td>X ray radiography</td>
</tr>
<tr>
<td></td>
<td>Ultrasonic pulse velocity</td>
<td>Ultrasonic pulse echo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Radar</td>
</tr>
<tr>
<td>Structural integrity of concrete structure</td>
<td>Proof loading (load deflection)</td>
<td>Proof testing using acoustic emission</td>
</tr>
</tbody>
</table>

Non-destructive test methods are used to identify internal details of structural elements such as the location, size and condition of reinforced bars, but are not directly used to assess the strength of concrete. In this case correlations must be established between the non-destructive test data taken on site and the strength values of cored samples established in the laboratory, in order to provide estimated in-situ strength of structural concrete members. Each technique has its own merits in terms of relative cost, speed and reliability.
Accurately measuring moisture in wall and floor materials is difficult and a variety of instruments are used. (See table below) The electrical resistance meter is a particularly useful tool for instance in monitoring the rate at which moisture content is changing. Great care has to be taken, however, in the interpretation of results, as a distinction has to be drawn between the presence of soluble salts and actual moisture content of the material being tested.

A sampling plan might have to be drawn up and a property revisited on a number of occasions to record the results of electronic and other monitoring equipment, such as determining the cause of movement in a building symptoms when manifested themselves in the form of cracking and evidence of suspected settlement.

These examples of testing and monitoring serve to illustrate the need for meticulous planning prior to undertaking an investigation of defects. This particularly applies when taking drilled samples of floor and wall materials when it is required to determine moisture content using a carbide meter. Where numerous samples are necessary it may be more convenient to test materials in the laboratory to establish moisture content and hygroscopic moisture content. In these and similar cases the whole logistical process of accurately recording the location of the samples taken and the corresponding test results must be meticulously managed.
Table 3.3. Measurement and testing instruments

<table>
<thead>
<tr>
<th>Instruments for Measuring Moisture and Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical resistance moisture meters</td>
</tr>
<tr>
<td>Resistance gauges</td>
</tr>
<tr>
<td>Microwave techniques</td>
</tr>
<tr>
<td>Sampling by independent cores</td>
</tr>
<tr>
<td>Thermo hygrograph</td>
</tr>
<tr>
<td>Electronic sensors</td>
</tr>
<tr>
<td>Wet and dry bulb thermometers</td>
</tr>
<tr>
<td>Dew point sensors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non-destructive testing of building services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition monitoring by thermography</td>
</tr>
<tr>
<td>Thermal imaging using an infrared camera to detect heat build-up in faulty electrical and electronic circuits; frictional heating eg bearing wear; detecting heat loss from a building fabric (can also detect damp material which is colder than dry material)</td>
</tr>
<tr>
<td>Endoscopy</td>
</tr>
<tr>
<td>Fibre optics to examine inaccessible ducts and voids</td>
</tr>
<tr>
<td>Ultrasonic pulse velocity</td>
</tr>
<tr>
<td>To detect flaws or material thickness e.g. corrosion of pipework; voids or delamination in concrete</td>
</tr>
<tr>
<td>Eddy current testing</td>
</tr>
<tr>
<td>Electromagnetic technique used on conductive materials to detect cracks, flows, size or material variations</td>
</tr>
<tr>
<td>Covermeter</td>
</tr>
<tr>
<td>Location or reinforcement and estimating cover thickness</td>
</tr>
<tr>
<td>Schmidt hammer</td>
</tr>
<tr>
<td>For estimating concrete strength</td>
</tr>
</tbody>
</table>

In assessing the damage caused in a defective building it is useful to have some objective measure in making the assessment. Such a technique is particularly useful where a large building complex or a number of properties are the subject of the investigation and where, consequently a team of building surveyors has to be deployed. An example of using such a technique can be applied in the investigation of cracks caused by the distortion of a building structure. Building surveyors/construction experts will refer to a classification of visible damage – surface symptoms and not causes – to walls on a scale which ranges from
1 (negligible up to 0.1mm wide) to 5 (very severe >25mm wide). Crack monitoring instruments and aids are used to determine crack shape, size and depth, and to the extent of horizontal and vertical direction of movement over time. Using this diagnostic method the surveyors can build a picture of the location and scale of cracking which are indicating the presence of shearing, compressive or tensile stresses.

Some cases necessitate monitoring the rate of development of a defect over a prolonged period of time in order to assess the form and probability of failure. Examples include measuring the width of cracks in walls by inserting drilled and plugged brass screws and using a micrometer to take levels at fixed points in order to assess the rate of settlement, as well as checking vertical alignment using a theodolite.

The investigation may necessitate the input of a small builder to attend site to open-up and make good the building fabric after the building surveyor’s inspection and this has to be costed, planned and managed. Examples of where opening up would be necessary are:

- Removal of facing brickwork around window openings to inspect rain excluding detailing e.g. damp proof courses
- Cutting access panels in plaster board ceilings and wall panels to gain access to voids
- Lifting ceramic floor tiles to inspect floor structure
- Removing areas of flat roof waterproof cover to determine form of construction.

3.1.3 Repair appraisal and selection

In diagnosing defects the approach adopted should be to carefully examine all the symptoms presented, consider and assess all the possible and probable causes, and then by a process of systematic elimination identify the actual cause and its source. This process should then lead to a decision on determining the appropriate and optimal course of remedial action.

The diagnostic phase of the investigation process - whether implicitly or explicitly expressed - involves testing hypotheses in order to clearly establish the cause(s). In effect the analysis phase overlaps with the diagnostic phase in narrowing down the possible causes of a defect to one which is considered the most likely or where the evidence puts it beyond doubt.
The investigative process is then at the stage where the surveyor can determine and specify remedial work to cure the problem and prevent its reoccurrence elsewhere. The process concludes with the production of a technical report which details how conclusions have been arrived at and which contains recommendations and actions on the way forward. The report may also cover issues of liability, insurance, quality assurance, implementation in occupied premises, forms of contract and procurement, and almost certainly provide cost estimates and advice on priorities and programming.

The evaluation of repair options draws upon the experience of the building surveyor/construction expert and is usually undertaken with the support of specialist suppliers and contractors. For example if faced with glass failure in curtain walling systems, the causes can be complex and easily misdiagnosed. A specialist installer or relevant trade association representative would advise on the glass specification and performance, glazing method and glass support.

In many cases different repair options will be available to the surveyor. These options will be evaluated against criteria such as cost, available funds, technical feasibility, practicality and impact on building users. Often the choices include taking no action, providing a temporary fix or alternative permanent corrective measures, according to whether the defects affect the building aesthetics, serviceability, functionality or structural stability. Remedial methods may be specified together with further preventative measures. In some parts of Europe for example where algal and fungal growth proliferates on external wall surfaces, remedial methods might include removal by high pressure water jetting, treatment using fungicidal wash and re-painting with algal resistant paint. Concurrent preventative measures in this case might provide for the avoidance of rough wall surface textures, the use of overhanging roofs, cappings and copings to protect walls and shed rainwater.

A further illustration of this point might be the deterioration of an external painted surface by the erosion of the pigment content. Remedial methods include removal of the powdery unstable paint film and repainting with an appropriate coating system. Preventative measures would include the selection of more stable paint colours and the application of appropriate coating systems used successfully elsewhere in similar circumstances.

Optimising the selection of the most effective and economic repair method is a technical decision for the building surveyor. The decision on whether or not to proceed is for the client. The client is guided in choosing the optimal repair solution by the surveyor’s technical report. Where the estimate cost of remedial
works is high, the client may decide to demolish or change the use of the building, combine the work with a planned retrofit, or pursue other options.

There are occasions when the optimal choice is to manage the consequences of a defect rather than take costly and disruptive corrective action. A case in point is that of ground water leaking into basements. Groundwater under pressure seeps in through the walls and floor, mainly through discontinuities in the construction such as cold joints, movement and structural joints, porous concrete, cracks or through service pipe penetrations. Waterproofing membranes, admixtures, cementitious based repair systems or drainage details may have been inappropriately selected or detailed at design stage; concrete insufficiently compacted, or poorly installed or damaged waterproofing applied during construction. Whatever the cause, continual water ingress may persist without causing structural damage or instability, but the client may choose to tolerate the consequences and decide to manage the situation by pumping out the water and screening the points of water entry.

Once the preferred remedial option is selected, the management process then proceeds to specification stage – by performance or prescriptive specification – and to procurement of the building work. By the very nature of the work there is an element of the unknown in carrying out defect repair work and there are measurement and pricing conventions to suit this scenario. When organising repair work the quantities sometimes have to be very approximate unless considerable effort has been made expended on surveys during the pre-contract phase. With concrete repair work for example, the quantities schedule in contract documents should indicate the range of types of repair by method and area or volume, and provision made in the contract for re-measurement of the actual repairs carried out. Almost inevitably with concrete defects, it is only when full access is available that the true extent of preparation and use of cementitious, resin and epoxy mortars can be quantified. It is often difficult foreseeing the full extent of concrete repairs required in large and tall buildings, despite conducting a thorough investigation to determine the extent and nature of repairs prior to letting a contract.

Suitable standard forms of contract should be selected for repair work. The bill of quantities should include heads of terms which reflect the nature of this type of work:

- Sample and trial panels
- Carrying out surveys simultaneously
- Preparation and submission of survey data
- Provision of physical access
Temporary works
Attendance of other trades
Attendance for inspection and testing
Facilities/equipment for inspection and testing
Approximate measured quantities
Re-measurement upon completion

Any trials which may be required either to test the repair method or to assess the finish and appearance should be fully described and the required performance levels of tests should be stated in the documentation. Where detailed survey work proceeds as part of the repair contract, utilising the scaffolding or other means of temporary access provided, then a programme should be devised for executing surveys and repairs in tandem to optimise the contract period.

There can be unforeseen delays with repair contracts and this has to be reflected in the contract documentation. Inspection and testing are likely to take place shortly before the actual repairs are carried out and decisions on the repairs required will be needed immediately. The inspection and testing required may be either of the original construction – where a pre-contract survey was only conducted to a limited extent – or of the actual repairs undertaken. The extent and purpose of these activities should be set out and the contractor invited to cost for attendance and providing any necessary equipment.

The object of providing detailed schedules for pricing is to provide sufficient information for the probable cost to be estimated with reasonable accuracy, for valuing the work in progress and to enable the final account to be fairly agreed with all parties. It remains common practice that clients and surveyors pass the risks on to the contractor or specialist companies in diagnosis faults and using their own repair methods. This procurement method can result in excessive or inappropriate work being carried out and contributory causes of defects are often ignored in the process.

Recommending remedial work, including rectifying source causes, can be difficult in some circumstances as there are so many variables to consider due to the alternative techniques and materials used in repair work. The client should be made fully aware of the cost implications, not only the initial capital outlay but also any future maintenance costs.

The remedial work chosen may fall into three broad categories: patching up, replacement of defective parts only or complete renewal. Patching up is often resorted on grounds of cost, but this may be due to ignorance of source causes.
This type of repair action should generally be regarded as a temporary measure, to be employed where the building has a limited functional or economic life and when more extensive refurbishment or improvement works are planned in the near future. Complete renewal may be the most economic solution for buildings with a longer life expectancy.

In any one of these alternative courses of action the faults need to be properly corrected to prevent a repetition of the same defects and as a general rule only techniques, materials and components which are well tried and tested should be used. Supervising the solution can be difficult particularly in renovation and repair work, and the employment of skilled and reliable operatives goes a long way to achieving the desired results and high standards of workmanship. Dependent on the supervisor’s confidence in the contactor, a renewal method might be chosen in preference to replacement of parts.

Producing a detailed specification and accurate plans are obvious pre-requisites for procuring a satisfactory job, but the work proposed must be realistic and buildable. Once the repair works are complete, periodic inspections provide the opportunity for early signs of failure to be recognised and for further costly repairs to be avoided by the carrying out of preventative maintenance. In this way useful information is collected which can serve as useful feedback for dealing with similar problems in the future.

**3.1.3 Strategies for prevention and mitigation of defects**

Despite the wealth of information and experience available on feedback from defect analysis and remedial work, common building defects continue to recur. Disseminating good practice information on design, specification, construction and maintenance practices has to be continually reinforced and practised.

Strategies to prevent and mitigate the effects of building defects can be grouped under the following headings:
- Importance of initial design and specification
- Getting the construction right
- Effective maintenance including the provision of access for inspection

Appropriate good practice guidance is published and made available on websites by a variety of industry organisations, including trade associations, universities, research and professional institutes, manufacturers and suppliers.
The guidance will vary in each country according to traditional methods of construction, materials used and other factors. In all cases however, a fundamental knowledge of building science and structural concepts underpins the practice of managing building pathology. Examples of these basic principles range from: understanding dimensional stability and differential movement in materials and structures; mechanisms of heat transfer and air permeability in the building fabric; relative humidity and dew point, to knowledge of bimetallic corrosion.

It is essential that building surveyors/construction experts and facility managers are involved in the design and specification process and that they can draw upon comprehensive building and maintenance records. Too often insufficient regard is given by designers to providing suitable access for inspection and maintenance. With well thought out planning will come the right approach to specification and detailing to reduce the need for unnecessary maintenance tasks and to facilitate access to those building elements where maintenance is unavoidable. The methods by which windows and facades are to be regularly cleaned and the way that planned maintenance can be executed, must be considered at an early stage in the design so that the necessary equipment can be incorporated into the structure of the new or refurbished building. Access is necessary for periodic inspection, servicing, replacement, upkeep and for undertaking protective measures. Whether permanent or temporary means of access is provided depends on the balance between capital outlay and running costs, life cycle costing, disruption to users and to consideration of aesthetics. It is incumbent upon the designer to understand the detailed maintenance needs of each particular building: anticipating where and how often maintenance will be required; the ability to physically reach each task position safely; space requirements; running or shut down maintenance; equipment, materials, parts and waste; and risks posed to occupants. This requirement applies to all types of buildings and not just those large and prestigious structures where it is common practice to install continuous fall arrest systems, suspended powered roof cradles and custom built boom and scissor lifts.

Whilst planning and careful detailing at the design stage can facilitate safe and efficient maintenance, the designer must also consider reducing the need for maintenance. For instance, the use of better quality and durable materials may reduce or eliminate the necessity for regular maintenance tasks in inaccessible locations. Constraints of cost, expected quality and performance will have a bearing on whether or not to specify a more durable but expensive material or type of equipment, or whether a task can be made simpler by accepting more utilitarian finishes. The right choice of materials, finishes and components can
reduce the maintenance load considerably. This partly relies upon well considered detailing and planning to anticipate the range of maintenance which will be required. As well as designing the building to facilitate ease of maintenance, the architect or engineer should also take care when specifying components that they will in themselves, allow for ease of maintenance. By appreciating where good and bad situations exist through observation, and trying to understand why this is so, many simple and effective design solutions will present themselves. Roof overhangs provide solar shading but also serve to protect external walls from rainfall and help keep facades dry and clean. Similarly the attention to detail in designing and constructing copings, cappings, abutment flashings, vapour control layers, damp proof courses and membranes will pay dividends in preventing situations where defects might arise.

Building services tend to be covered up for aesthetic reasons, safety or for hygienic purposes. Access must be built in for inspection to vertical or horizontal ducts, ceiling and floor voids, and to internal and external pipework and services run below ground for inspection. Major runs of building services internally often follow circulation routes within buildings, which is less disruptive to occupants. Throughout the building and external grounds, the designer must anticipate the worst possible scenario in having to make good during remedial works and provide easy, fool-proof access, together with the use of durable and replaceable materials in those areas likely to be subjected to maintenance.
CHAPTER 4

PLANNING AND FINANCE

4.1 THE MAINTENANCE PLANNING PROCESS

Accurate good quality maintenance cost forecasting is important for any business or organisation for a number for reasons. Future repair and replacement requirements have to be identified and planned for; funds have to be in place to meet identified maintenance needs; accurate forecasting of future maintenance costs is invaluable in assessing the viability of new schemes; owners and funders will be keen to make the best use of premises to protect the value of the asset base and as security against loans, and from a value for money perspective good quality maintenance forecasting helps maximise the best use of resources.

Forecasts need to be revised and updated over the course of time. Long term forecasts will need to be revised as more accurate projections become available and to take account of external financial, economic or regulatory changes. Medium term forecasts will need revising as annual operational plans are implemented.

An effective system takes into account the cost of postponing maintenance activities. Work which if delayed will rapidly increase in cost with time should take priority over work where this is not necessarily the case. Work prioritisation must be linked to performance loss and cost growth as a result of delayed maintenance.

Historical costing is a standard method of forecasting future costs based on the examination of previous costs, which in turn relies upon the level of detail recorded and the ease with which information can be retrieved. At its simplest this method is used to predict responsive and planned maintenance costs for the forthcoming year based on the previous year’s outturn costs, whilst adding
for inflation. More refined methods would be to average costs over a number of previous years or make reference to costs by property type. These methods are reliant upon having good systems in place to collate and record data on maintenance and repair activities and costs.

Historical costing is a quick and inexpensive method for predicting budget figures for responsive repairs as trends in costs can be projected over the short term. However, with changing variables such as maintenance policies or cost inflation, long term projections on this basis are less reliable.

The benefits of a planned rather than an unplanned approach to maintenance are generally understood in most organisations although not always put into practice. A policy of regular surveys and inspections of property provides the means by which a significant proportion of otherwise unpredictable defects and faults may be reasonably anticipated and managed through a planned programme. Good practice suggests that a building condition survey conducted every 5 years provides the basis upon which a maintenance programme can be developed. The building surveyor/construction expert can reasonably be expected to make accurate judgements on the life remaining of different building elements over a 5 year cycle, and to observe any defects and signs of imminent failure.

![Fig. 4.1. Cycle of building survey and inspection](image_url)
The output from this building condition survey identifies, prioritises and costs current and future repairs and replacements. Work of an emergency and urgent nature which is identified is then carried out in conjunction with user reported defects and faults, through the reactive maintenance process. The 5 year programme sets out in detail which building elements and components will require remedying, replacement or improvement.

During the maintenance planning process, the objective of the annual inspection of those properties identified in the longer term programme is to update and refine the work identified for budget preparation purposes. In other words to prepare the detailed budget for the following year, all those properties in the 5 year programme with works identified, will be re-inspected during the current year. Optimising decisions can then be made on whether to group items to take advantage of economies of scale by delaying or bringing forward related planned work to a group of properties. It will for example almost certainly be more cost effective on high rise blocks to group items of work into a single contract where costly scaffolding or other access equipment has to be provided. This might require decisions to replace items – windows or wall cladding – ahead of their expected life expiry. In other cases it might be considered prudent to stop trying to extend the life of an element by continual repairs and to undertake preventative maintenance measures before their anticipated life expiry, to avoid the inevitable disruption and consequential damage caused if they failed prematurely.

One recognised benchmark for planned versus unplanned maintenance expenditure sets a target ratio of 75%:25%. Alternative yardsticks have been put forward for an annual maintenance budget or sinking fund investment which varies between 1.5 % and 2.5% of the insured value of a the property estate. It can prove to be a good discipline within businesses and organisations to adopt similar yardsticks when reviewing their maintenance strategies and policies. There will be an optimum balance between planned and unplanned budgets to suit each business and organisation and the opportunities provided by asset management software to analyse data, enhances the chances of success in achieving these exacting targets and to gain cost efficiencies and improved value for money.

The preparation of a maintenance programme is undertaken on the basis of regular and systematic appraisal of buildings in a portfolio, but it is also considered to be good practice to encourage all building users to continually report items requiring attention. Low cost software and internet access is now
freely available to allow building users to log issues online and thus help maintenance personnel to manage remedial work more efficiently.

Every maintenance programme will need to allow a contingency sum to cover unplanned and unforeseen work. The prudent manager will identify at the start of each financial year, those items of work planned for year two which could be brought forward in the event of surplus funds being made available in the unplanned budget or through additional finance. The corollary to this is where there is overspend on unplanned items then the planned budget suffers and work is put back until year two.

One further consideration in undertaking preventative maintenance planning is including investigative and remedial works into programmes where early symptoms of failure are detected, which if left untreated might generate consequential damage with considerably greater cost implications. Building defects can lead to: structural instability; disruption to users; hazards causing loss of service; unsightly and uncomfortable conditions; impaired fitness for purpose and diminished values of assets. Correct diagnosis of the causes of defects, however, ultimately depends on the skills of the building surveyors/construction experts undertaking the inspections.

4.1.1 Planned maintenance programmes

Chief amongst the eight objectives Wordsworth identifies when defining the objectives of a maintenance plan are: ensuring that the building fabric is maintained to a defined, acceptable, safe and legally correct standard; preserving utility and value; optimising condition and taking preventative action; cost effective planning and providing financial management and budgetary control. In the hierarchy of maintenance programmes adopted by individual organisations, the longer term plans by their very nature – whether they are for five or ten years or longer – lack the detail of annual programmes. They are, however, invaluable in supporting bids for resources and for setting an overall property asset strategy (Lee 2000).

Some banks and other funders when underwriting publicly funded projects require 50 or 60 year life cycle replacement and maintenance cost projections. Clearly there are caveats in such forecasts related to the anticipated service life of elements and components, technological developments, standards of maintenance and many other factors. Indicative budget costs are applied
in these calculations, from sources based on standard industry experience. See sample below. Refer to ISO 15686 Buildings and constructed assets-service life planning: Part 8, for data on service life and service-life estimation.

The essential feature of a planned maintenance system is that failures are anticipated – in so far as they reasonably can be – and appropriate procedures and systems are put in place for their prevention and rectification. Forward planning of budgets and expenditure empowers building owners and occupiers by allowing them to remain in control of costs as far as practically possible. There are substantial advantages – economic, business efficiency and service delivery – to adopting a planned approach, where the majority of the expenditure is allocated to planned maintenance. This section considers the key issues involved in implementing a planned approach to maintenance and in securing value for money, whilst dealing with the challenges managers face in a constantly changing operating environment.

Maintenance plans should flow from the property asset strategy, which in turn contributes to and is informed by, the overall business plan for the organisation. What then should the maintenance plan look like and how is it developed? Every business and organisation with a property portfolio needs a 5 or 10 year maintenance plan and programme (see sample extract below). Service companies who manage properties – perhaps under outsourcing contracts – will also have a commercial interest in working to a 5 year plan.
## Table 4.1. Extract from 5 year maintenance plan

<table>
<thead>
<tr>
<th>Element/Component</th>
<th>Sub element/component</th>
<th>Work item</th>
<th>Year 1-2</th>
<th>Years 3-5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roofs</td>
<td>Flat roof structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flat roof coverings/insulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flat roof drainage</td>
<td>Clear flat roofs and outlets to block A</td>
<td>€ 1,000</td>
<td>€ 1,000</td>
<td>€ 2,000</td>
</tr>
<tr>
<td></td>
<td>Flat roof other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pitched roof structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pitched roof coverings/insulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pitched roof drainage</td>
<td>Repair leaking gutter joints to IT street</td>
<td>€ 1,200</td>
<td></td>
<td>€ 1,200</td>
</tr>
<tr>
<td></td>
<td>Pitched roof other</td>
<td>Block B upgrade insulation and cross ventilation</td>
<td></td>
<td>€ 3,000</td>
<td>€ 3,000</td>
</tr>
<tr>
<td>Floors and stairs</td>
<td>Ground floor</td>
<td>Annual allowance for replacing carpet</td>
<td>€ 2,000</td>
<td>€ 2,000</td>
<td>€ 4,000</td>
</tr>
<tr>
<td>Ceilings</td>
<td>Suspended ceiling tiles</td>
<td>Annual allowance for replacing tiles</td>
<td>€ 1,500</td>
<td>€ 1,500</td>
<td>€ 3,000</td>
</tr>
<tr>
<td>External walls, windows and doors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walls structure</td>
<td>Walls external lining/finishes</td>
<td>Re-point brickwork to block A at upper roof level in small patches</td>
<td>€ 1,000</td>
<td></td>
<td>€ 1,000</td>
</tr>
<tr>
<td></td>
<td>Walls external lining/finishes</td>
<td>Re-point brickwork in areas to Science south side 20m2 ground and upper levels</td>
<td></td>
<td>€ 750</td>
<td>€ 750</td>
</tr>
<tr>
<td></td>
<td>Walls external lining/finishes</td>
<td>Re-point brickwork in areas to Science east side 16m2 and repair crack at second floor</td>
<td></td>
<td>€ 1,500</td>
<td>€ 1,500</td>
</tr>
<tr>
<td></td>
<td>Walls external lining/finishes</td>
<td>Re-point brickwork in areas to Science west side 60m2 at second floor</td>
<td></td>
<td>€ 1,000</td>
<td>€ 1,000</td>
</tr>
<tr>
<td></td>
<td>Walls external lining/finishes</td>
<td>Seal gaps and replace missing sealant in joints on west and east sides</td>
<td></td>
<td>€ 1,000</td>
<td>€ 1,000</td>
</tr>
<tr>
<td></td>
<td>Walls external lining/finishes</td>
<td>Repair brickwork crack, re-point and fill window cill joints</td>
<td></td>
<td>€ 750</td>
<td>€ 750</td>
</tr>
<tr>
<td></td>
<td>Walls external lining/finishes</td>
<td>Replace movement joint sealant</td>
<td></td>
<td>€ 300</td>
<td>€ 300</td>
</tr>
<tr>
<td></td>
<td>Walls external lining/finishes</td>
<td>Allow for ongoing repairs to render system</td>
<td></td>
<td>€ 5,000</td>
<td>€ 5,000</td>
</tr>
<tr>
<td></td>
<td>Walls external lining/finishes</td>
<td>Re-point Library wall in patches 50m2</td>
<td></td>
<td>€ 2,000</td>
<td>€ 2,000</td>
</tr>
<tr>
<td></td>
<td>Walls external lining/finishes</td>
<td>Re-point block D wall at ground level 2m2</td>
<td></td>
<td>€ 2,500</td>
<td>€ 2,500</td>
</tr>
<tr>
<td>Windows and doors -framing</td>
<td></td>
<td>Replace 2 No windows on north side of Science</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

65
Depending upon the type and complexity of the property portfolio, the maintenance plan and programme may include heads of terms such as the following:

- Direct labour cost for day to day or responsive repairs
- Contractors costs
- Overhead costs
- Testing and servicing of electrical and mechanical plant and equipment
- Cyclical decoration
- Cyclical replacement of furnishings
- Minor projects (<125,000 Euros)
  - Improvements
  - Insurance related work
  - Energy efficiency measures
  - Disabled access requirements
  - Security installations
  - Roads and drainage
- Major works (>125,000 Euros)
- Contingency
- Utility supplies – gas, electricity, water, drainage, telecoms
- Cleaning and refuse
- Local taxes and insurance
- Security cover
- Grounds and gardens
- Health and safety management

One of the principal objectives in moving to a planned approach is to minimise expenditure on reactive or day to day maintenance. These latter tasks are by their very nature, small isolated jobs, which can be time consuming to complete and costly to administer and execute to a good quality. Reactive maintenance jobs are usually reported by building users, often through a helpdesk. This type of maintenance is delivered and managed as a service, with procedures and systems in place for reporting the repairs and carrying out the work to meet pre-defined standards.

The maintenance plan for any business or organisation has to strike a balance between scheduling or programming actions and expenditure, and a contingency process for dealing efficiently with the unforeseen need for repair and maintenance. Scheduling work such as planned preventive maintenance to boilers and air conditioning units, and capturing repair and maintenance work from planned inspections, provides information for the plan preparation process.
Identifying maintenance needs over a 5 year period will involve collating information from sources such as:

- Regular building condition/statutory compliance surveys
- Feedback from existing maintenance programmes
- Plant and equipment servicing reports
- Pre-acquisition survey reports
- Lease covenants
- Health and safety risk assessments, files and plans
- Operation and maintenance manuals and log books
- Reactive repair records
- Energy audits and other specialist surveys and assessments

In developing the maintenance plan and programme, the longer the lead-in time allowed, the more detailed the preparatory work that can take place and the less likelihood there will be of delays due to unforeseen work and lack of resources. Each business and organisation establishes over time a minimum or an optimum level of resources to allocate for maintenance needs. The maintenance work may be procured either with a directly employed workforce, be outsourced to contractors or as is commonly the case, purchased through a combination of both to meet seasonal peaks and troughs in demand.

Planned maintenance of building services is generally organised according to a widely recognised procedure. It can either take the form of preventative maintenance, condition based or reliability centred maintenance. Plant and equipment where condition monitoring could be technically and financially justified, would be those which are expensive to maintain or replace, or where failure would lead to high consequential costs and where their operation is business critical. When managing building services, the building surveyor/construction expert will rely upon information from the asset register, operation and maintenance manuals on timing and frequency of tasks, together with knowledge of the resources required in formulating the maintenance plan.

There are uncertainties inherent in putting together a programme of maintenance work and consequently the plan needs to be flexible to allow for change. Managing risk in these circumstances is a key task of the surveyor. Delays and adjustments could arise for any number of reasons, including building use, occupant activity, pre-contract investigations, the seeking of approvals and funding availability.

Following completion and approval of the 5 year plan, the planning process continues with a detailed annual inspection of the building(s) in the year prior
to execution. The items flagged in the 5 year plan are included in this inspection together with other issues that might have subsequently been identified by occupants and users. This detailed and costed programme is put forward in the form a report to the client for approval in sufficient time to fit with the procurement process. The report will make reference to the consequences of delaying works and any unforeseen disruptive effects on the client’s activities.

4.1.2 Cost and financial management

Planned maintenance, improvement and major repairs are mainly funded through capital expenditure as annual revenue income would be insufficient to cover the cost of these works. Delivering this type of work is, therefore, best funded from capital borrowing and/or grant or from other receipts. Response and cyclical maintenance work – servicing, painting, cleaning and maintenance work undertaken on a specified cycle – is normally funded from annual revenue budgets.

In addition to taxation and accountancy considerations, it is important to distinguish between maintenance costs for which are committed and those which are variable or discretionary. Committed costs would arise from contractual liabilities, mandatory statutory obligations and lease covenants. Discretionary costs include all those planned, reactive and cyclical maintenance items which may be required to keep the property in a good standard.

The ownership and management of property naturally influences how maintenance work is funded. For example where development has been financed by Private Finance Initiative or Public Private Partnership, the liability for maintenance under a 30 year contract, will lie with the service provider. It will be in their interests as a general rule to seek to minimise expenditure and seek value for money. The total running costs over this period substantially outweighs the initial construction costs and consequently maintenance and replacements have to carefully planned. Similarly a tenant who leases premises may not be interested in investing in an on-going programme of repair work but instead seek to negotiate the settlement of a dilapidations claim.
4.1.3 Costing and budgets

Funds spent on maintenance is often perceived as offering no return and consequently it is frequently prone to cut backs and to re-direction elsewhere in the organisation. The maintenance budget is easily pruned and expenditure is deferred. The budget is, therefore, of vital importance and needs to be precise, based on good quality data and be well presented. Furthermore as a tool for planning, control and measurement, the budget must be convincing and evidence based.

The maintenance budget has to be approved by corporate planners and managers and relied upon by the finance personnel within an organisation. The way in which the budget is presented by the building surveyor/construction expert is important when seeking support and approval must provide evidence of the following:

- An objective assessment of technical needs across the property estate.
- Reflect the systematic budget planning process of identifying need, priorities and accurate cost estimating.
- Give recognition to long term implications and priorities.
- Relevant to the needs of the users
- Provide value for money
- Set out implications for deferring expenditure
- Fit with the organisation’s overall objectives and budget.

The budget is invariably set out in part in the form of a spreadsheet format. This financial statement of proposed expenditure is typically broken down into sub-totals to reflect the following:

- Type of work
  - minor work
  - planned maintenance
  - reactive
- Cost centres
- Resource type:
  - labour
  - materials
  - plant
  - overheads
- Procurement type
- Scheduled expenditure
  - monthly
Maintenance programmes need to be costed accurately. The different components in the programme will have costs allocated by reference to historic records, standard reference pricing books and online subscription sources, competitive tenders, planned and ad hoc surveys such as a building defect reports. Where the principal source of planned maintenance information is the 5 year building condition survey then great care has to be taken in cost estimating during the survey process.

The basis of costing should be agreed and trialled in a pilot exercise prior to the commencement of the main survey on site. Some clients prefer to measure and estimate on site during the course of the survey whilst other prefer to undertake this as a desktop exercise after completion of the site inspections. Whichever method is chosen, a base date for costs is agreed and published indices will be used to update costs year on year to reflect current values. To ensure consistency of approach all surveyors and services engineers in the survey team will estimate repairs and replacements at current costs using a schedule of rates. The schedule will list for each building element the unit of measurement and the life expectancy value. Standard published or bespoke schedules of rates can be used, but both types should be underwritten with clearly expressed assumptions about the types of work and appropriate contract size.

Issues to consider when agreeing the cost estimating strategy for the 5 year maintenance plan surveys include: how accurately measurements need to be; when to apply spot pricing rather than composite rates; how preliminaries, contingency, professional and statutory fees and taxes are going to be applied. Furthermore it is common practice to exclude maintenance items which are routinely undertaken on a day to day responsive maintenance basis and to agree a “de minimus” rule whereby items with an estimated cost below a certain threshold are excluded. Composite rates in this context refers to a single rate for a standard replacement task such as installing kitchen fittings. In this example the composite unit rate could cover stripping out the old fittings and all the necessary joinery, plumbing, electrical, tiling works associated with providing the replacement fittings. All cost estimates for maintenance programmes should be robust and capable of withstanding challenges.

Realistic budgets must be set and they should then be monitored regularly. Apart from budgeting for planned maintenance, budgets need to be put together for cyclical maintenance and responsive repairs. Cyclical maintenance budgets
are generally the most straightforward to define and set. They are usually based upon analysis of historical data although it is important to have up-to-date information.

Budgets for cyclical maintenance and planned programmes should be smoothed to even out spending and cash flow year on year. The process of budgeting involves: constant checking and review of performance against proposals and in-built flexibility to enable the surveyor to make adjustments.

4.1.4 Cost control

Controlling expenditure of the overall allocated budget for the year is built up from monitoring the finance allocated on individual jobs and projects. Overspending and under spending on individual projects can be balanced within the context of committed expenditure. During the course of the year, actual committed and planned expenditure are plotted in a spread sheet and charts, and any significant deviation will prompt corrective action to ensure that programme delivery is on course for example. Annual inspection and servicing contracts for air conditioning plant may reveal greater than anticipated deterioration and increased failure rates, which may prompt emergency demands on the budget.

Variance reporting at regular intervals is a technique whereby differences between actual costs and those forecast can be analysed in preparation for corrective action. This action can take the form of deferring the work or reduce the scope of the programmes work, where the variance reporting shows the budget is overcommitted. Conversely pre-prepared schemes can be brought forward where under expenditure is forecast.

The annual maintenance programme will be an essential tool for planning the optimisation of resources where there is a directly employed maintenance team. The procurement of materials and components can then proceed on the basis of this programme.

The maintenance budget represents the planned course of action over a specified time period. Cost control using the budget is a management tool, whereby information can be reported - in a graphical or numerical format – on out-turn costs, exceptions, committed expenditure and trends. A system of analysing costs is essential in identifying how and where costs have been incurred, which can prove to be invaluable as an indicator for future actions.
The information generated by a management system can assist in identifying deviations from plan and where decisive action is required. The actions required of managers then help to optimise the use of all resources.

4.1.5 Performance management

Delivering value for money (or best value) and meeting customer and user expectations in the standard of service delivered are key drivers for those organising maintenance operations. Arrangements need to be put in place covering service quality and performance benchmarking and measurement. This requires specifying performance criteria at the outset, whether the work is to be undertaken in-house or contracted out, to enable the effective capture of information needed for performance management.

Benchmarking maintenance costs is an important process for an organisation but perhaps particularly for small to medium sized enterprises, where they do not have the benefits of large volumes of work and constant market testing through competitive tender or procurement through framework and partnership agreements.

Sources of data for benchmarking maintenance costs vary by economic sector and type of organisation. There are national published databases that managers can subscribe to and specific sources for example which are maintained by the healthcare or education sectors. Professional institutions, government agencies and commercial organisations provide benchmarking websites.

Benchmarking is a popular technique used for peer comparisons of cost and resources. Like for like comparisons help managers understand where opportunities exist for efficiency gains in managing estates. Benchmarking means looking outside the organisation or business and measuring or comparing against a standard. High level benchmarking analysis will often suffice as more detailed exercises will be administratively time consuming.

Typically a commercially available dataset would include approximate estimates; tender and cost indices; building cost models; detailed prices for measured works and fees for professional services. An international benchmarking service is available from Investment Property Databank Ltd (www.idoccupiers.com) they provide property performance measurement tools and benchmarks for corporate real estate and facilities management. Benchmarking clubs within each sector or those which have been set up
on a geographical basis as a self-help forum can provide a valuable service. The assessment of building and maintenance performance can be measured in terms of:

- Long-term reduction in lifecycle costs
- Extending the life of assets
- User or customer satisfaction
- Improved asset service and safety standards
- Operational outcomes such as energy consumption, operating costs, health and safety targets.

Service standards should specify the customer, operational and technical criteria to be met by the building maintenance arrangements. Specifying the level of service standard of course determines the level of resource required. Maintenance key performance indicators (KPIs) are in common use to monitor and improve performance. How the data is collected is vital to obtaining meaningful and accurate results which will then enable improvement plans to be developed.

Key Performance Indicators are a means of measuring the performance of all parties involved in a maintenance contract. These measures are defined at the outset of the contract and need to be tangible and clearly measureable (see example at fig. 4.2).
Many organisations collect too much information – which has cost and processing implications – which is then not fully utilised. It is imperative that the fewest measures are adopted to enable performance to be managed effectively and economically. Landlords should be analysing in detail the underlying patterns of service use and trends in building performance. Information on performance is particularly useful when it is consistent and examined over time to analyse these trends and identify where corrective action needs to be taken.

Managers need to ensure that the key performance indicators are measuring what really counts in delivering the business plan rather than what is easy to measure. These measures need to relate to each other, encourage positive behaviours and reinforce values.

KPIs will be generated by the management information system. All contractors engaged in delivering a maintenance service will have access to data through a web based system. Performance indicators are in common use in managing responsive repairs and servicing contracts. Information is up-dated in real time.
by the use of the mobile devices, which facilitates speedy post inspection of work, reporting and customer feedback. Satisfaction surveys conducted by email or telephone on completion of work are essential for the building surveyor/construction expert in gauging how needs have been met and in managing expectations and perceptions. Users are requested to answer questions such as: consultation on the timing of the work; the time it took to execute the work; quality of work; whether the contractor was considerate and tidy.

Post inspection checks of a contractor’s quality and standard of work, should also include the building users’ satisfaction with company employees attendance record, attitude and workmanship. These inspections are usually carried out on a sampled basis. All performance measures are invaluable for driving a ‘right first time’ policy, ensuring that repair, maintenance and replacement work is defect free and that the costs arising from failure and poor standards of execution are minimised.

The key performance indicators selected for assessing the effectiveness of planned and cyclical maintenance will reflect the scope and content of this type of work. Standard measures will include progress against time, budget, costs, quality and customer satisfaction.
CHAPTER 5

MAINTENANCE INFORMATION
AND THE ROLE OF IT

5.1 SYSTEMS REQUIREMENTS
AND USES

Accessible, current and comprehensive information is essential for operational and strategic management of a property estate. Access to this information is required from mobile devices and this facilitates and encourages users to continually replenish data on site. Managers need a web based information management system that will provide them with convenient access 24/7 with up to date, complete, consistent and accurate data.

An adaptable system would allow the building surveyor/construction expert to continually seek to improve processes and procedures, work smarter, raise individual productivity, freely share information and raise the performance of managers in so many other ways. Initially the basic maintenance and property dataset need not be too sophisticated, but setting up a management information system does require an awareness of the potential benefits, resolve and some investment.

One activity that must not be underestimated is the investment required to replenish data asset management systems. This process covers keeping information up-to-date by closing off planned items as they are completed onsite and overwriting old surveys with new data.

This replenishment process is made easier where the data in a modular system is integrated. Thus editing records after installing new windows in a property would update the next replacement data for the new windows, satisfy a requirement set under a benchmark standard and trigger the calculation engine which generates an improved energy performance rating.
One technique that electronic data collection makes possible is that of cloning survey data whilst the surveyor is on site. This standard function in the software can be used to copy or clone data captured from a similar property. This technique proves useful for example where access cannot be gained to a property during a survey.

Very often because of the excessive cost involved in conducting planned maintenance surveys of an estate comprising thousands of properties, a sampling methodology is adopted. The property estate is classified into broad types or archetypes according to age, form of construction and size, a sample of each archetype is surveyed and the remainder are copied within the database from this sample. During subsequent surveys the cloned data is replaced with actual and current data on property condition.

Managers generally rely upon the availability of good quality information, including data relating to:

- Physical condition and current performance of property
- Costing, prioritising and planning of repairs, maintenance and improvement work
- Fitness for purpose and functional management
- Space utilisation – improving space
- Compliance with health and safety and other statutory regulations
- Tenancy and occupancy
- Property value
- Energy efficiency, environmental sustainability and climate change
- Facility management contracts

To specifically assist them at a strategic level, managers need a property information base which supports policy decision making and the development of maintenance strategies. Fundamentally they require access to a database that will provide them with information to:

- Assess the cost of raising their property portfolio up to a required standard
- Sustaining the property in the condition achieved
- Developing long and short term maintenance programmes based on objectively derived need
- Budgeting for future repair and improvement liabilities
- Ensuring and demonstrating compliance with regulatory standards and good practice
- Performance measurement and benchmarking
The interrelated needs of operational property asset management are ideally met from the same database as those required for strategic direction. Typically these more detailed requirements would include:

- Comprehensive data on all properties – type, floor area, construction, measurements and quantities – for managing maintenance on a day to day basis
- Detailed planning and programming of repairs for each property
- Assessing backlog maintenance and repair liabilities
- Access to risk assessment records, health and safety file and servicing records
- Building occupancy details
- Floor plans and visualisation models

One particular driver prompting business and organisations to maintain complete, accurate and consistent information is the need to comply with statutory law and regulation. Keeping abreast of changes in statute and how they impact on maintenance priorities and expenditure is an onerous task. For all building owners and occupiers this will include regulations covering workplace health, safety and welfare regulations; disabled access; hazardous materials; fire safety; water hygiene; energy conservation; sustainability and many more.

Health and safety regulatory compliance and the guidance which accompanies it often demand that records be kept. In the standard European Union five step risk assessment process, recording the findings, reviewing and updating the assessment are essential stages. Sometimes the guidance specifies the length of time that data has to be retained as well as recommending the frequency of re-assessment and inspection. An essential requirement of a management information system, therefore, is to provide an audit trail of data on test results, inspections and assessments, for recall for internal performance management purposes and by external regulatory enforcement agencies.

Managing the review and updating process of regulatory compliance is an onerous task, particularly with a diverse property portfolio such as a group of schools or a university campus. Alerting the manager of review dates would be a key system requirement. To illustrate the size of this task, the chart below provides an extract from a software package dedicated to managing school premises, which provides alerts for testing, inspection and servicing.
Table 5.1. Diary alerts in software for risk assessment, testing & servicing review

<table>
<thead>
<tr>
<th>Activity</th>
<th>Task</th>
<th>Mandatory</th>
<th>Due: m month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control of Substances Hazardous to Health</td>
<td>Dust &amp; fume extraction - test</td>
<td>Yes</td>
<td>10y</td>
</tr>
<tr>
<td></td>
<td>Dust &amp; fume extraction - inspection</td>
<td>Yes</td>
<td>12m</td>
</tr>
<tr>
<td></td>
<td>Local exhaust ventilation</td>
<td>Yes</td>
<td>14m</td>
</tr>
<tr>
<td></td>
<td>CDT &amp; science room extract systems</td>
<td>No</td>
<td>1d</td>
</tr>
<tr>
<td>Electrical</td>
<td>Portable Appliance Testing</td>
<td>Yes</td>
<td>1m</td>
</tr>
<tr>
<td></td>
<td>Fixed Electrical Wiring Installation Test</td>
<td>Yes</td>
<td>1m</td>
</tr>
<tr>
<td></td>
<td>Emergency Lighting - Monthly Test</td>
<td>Yes</td>
<td>1m</td>
</tr>
<tr>
<td></td>
<td>Emergency Lighting -6 Monthly</td>
<td>Yes</td>
<td>1m</td>
</tr>
<tr>
<td></td>
<td>Emergency Lighting - Annual Test</td>
<td>No</td>
<td>1m</td>
</tr>
<tr>
<td></td>
<td>Emergency Lighting -3 Monthly</td>
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<td>1m</td>
</tr>
<tr>
<td></td>
<td>Emergency Lighting -3 years</td>
<td>No</td>
<td>1m</td>
</tr>
<tr>
<td></td>
<td>Lightning Conductors</td>
<td>No</td>
<td>1m</td>
</tr>
<tr>
<td></td>
<td>Powered Pedestrian Doors - 6 Month Service</td>
<td>No</td>
<td>1m</td>
</tr>
<tr>
<td></td>
<td>Powered Pedestrian Doors - annual test</td>
<td>No</td>
<td>1m</td>
</tr>
<tr>
<td>Energy</td>
<td>Display energy certificate</td>
<td>No</td>
<td>1w</td>
</tr>
<tr>
<td></td>
<td>Energy performance certificate</td>
<td>Yes</td>
<td>1w</td>
</tr>
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<td></td>
<td>Air conditioning inspection</td>
<td>Yes</td>
<td>1w</td>
</tr>
<tr>
<td>Fire safety</td>
<td>Portable Fire Fighting Equipment - Annual service</td>
<td>Yes</td>
<td>1y</td>
</tr>
<tr>
<td></td>
<td>Fire risk assessment</td>
<td>Yes</td>
<td>1y</td>
</tr>
<tr>
<td></td>
<td>Audible Fire Alarm Weekly Test</td>
<td>Yes</td>
<td>1y</td>
</tr>
<tr>
<td></td>
<td>Fire Alarm Devices 3 Monthly Test</td>
<td>Yes</td>
<td>1y</td>
</tr>
<tr>
<td></td>
<td>Comprehensive Fire Alarms Test</td>
<td>Yes</td>
<td>1y</td>
</tr>
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<td></td>
<td>Fire Fighting Equipment</td>
<td>Yes</td>
<td>1y</td>
</tr>
<tr>
<td></td>
<td>Fire Fighting Equipment - Service</td>
<td>Yes</td>
<td>1y</td>
</tr>
<tr>
<td></td>
<td>Fire Drills</td>
<td>Yes</td>
<td>1y</td>
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<tr>
<td></td>
<td>Fire Safety Staff Training &amp; Instruction</td>
<td>Yes</td>
<td>1y</td>
</tr>
<tr>
<td>Furniture, Fixtures &amp; Fittings</td>
<td>Fixed sports and gymnasium equipment</td>
<td>Yes</td>
<td>1y</td>
</tr>
<tr>
<td><strong>External play equipment - Inspection</strong></td>
<td>Yes</td>
<td>1y</td>
<td></td>
</tr>
<tr>
<td><strong>PE/ Gymnasium Equipment and Playground Equipment</strong></td>
<td>Yes</td>
<td>1y</td>
<td></td>
</tr>
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<td><strong>Kitchen Equipment - Annual Inspection</strong></td>
<td>Yes</td>
<td>1y</td>
<td></td>
</tr>
<tr>
<td><strong>Kitchen Equipment - Visual Inspection</strong></td>
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<td>1y</td>
<td></td>
</tr>
<tr>
<td><strong>Gas</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gas Boilers - Annual Service</strong></td>
<td>Yes</td>
<td>1y</td>
<td></td>
</tr>
<tr>
<td><strong>Gas Appliances - Safety Check</strong></td>
<td>No</td>
<td>1y</td>
<td></td>
</tr>
<tr>
<td><strong>Gas Catering Equipment - Service and certification</strong></td>
<td>Yes</td>
<td>1y</td>
<td></td>
</tr>
<tr>
<td><strong>Gas (Flue) Guards</strong></td>
<td>Yes</td>
<td>1y</td>
<td></td>
</tr>
<tr>
<td><strong>Gas cylinders and equipment used for welding, cutting or similar processes</strong></td>
<td>Yes</td>
<td>1y</td>
<td></td>
</tr>
<tr>
<td><strong>Lifts and lifting equipment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lifts (Passenger) - Insurer Inspection</strong></td>
<td>Yes</td>
<td>2y</td>
<td></td>
</tr>
<tr>
<td><strong>Lifts (Passenger) - Planned Maintenance Inspection</strong></td>
<td>Yes</td>
<td>2y</td>
<td></td>
</tr>
<tr>
<td><strong>Lifts (Passenger) - Safety Gear Test</strong></td>
<td>Yes</td>
<td>3m</td>
<td></td>
</tr>
<tr>
<td><strong>Lifts (Non Passenger) - Insurers Inspection</strong></td>
<td>Yes</td>
<td>3m</td>
<td></td>
</tr>
<tr>
<td><strong>Lifts (Non Passenger) - Planned Maintenance Inspection</strong></td>
<td>Yes</td>
<td>3m</td>
<td></td>
</tr>
<tr>
<td><strong>Lifts (Non Passenger) - Safety Gear Test</strong></td>
<td>Yes</td>
<td>3m</td>
<td></td>
</tr>
<tr>
<td><strong>Lifts (Powered Stair) - Insurers Inspection</strong></td>
<td>No</td>
<td>3y</td>
<td></td>
</tr>
<tr>
<td><strong>Lifts (Powered Stair) - Planned Maintenance Inspection</strong></td>
<td>Yes</td>
<td>3y</td>
<td></td>
</tr>
<tr>
<td><strong>Mobile elevating work platform</strong></td>
<td>Yes</td>
<td>5y</td>
<td></td>
</tr>
<tr>
<td><strong>Roof cable systems for personal anchorage lines</strong></td>
<td>Yes</td>
<td>5y</td>
<td></td>
</tr>
<tr>
<td><strong>Window cleaning eyebolts</strong></td>
<td>Yes</td>
<td>5y</td>
<td></td>
</tr>
<tr>
<td><strong>Mechanical services</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Heating Installation - Half Yearly Servicing</strong></td>
<td>Yes</td>
<td>6m</td>
<td></td>
</tr>
<tr>
<td><strong>Heating Installation - Periodic Inspection</strong></td>
<td>No</td>
<td>6m</td>
<td></td>
</tr>
<tr>
<td><strong>Heating Installation - Annual Servicing</strong></td>
<td>Yes</td>
<td>6m</td>
<td></td>
</tr>
<tr>
<td><strong>Heating Installation - Calorifiers</strong></td>
<td>No</td>
<td>6m</td>
<td></td>
</tr>
<tr>
<td><strong>Air conditioning and ventilation</strong></td>
<td>No</td>
<td>6m</td>
<td></td>
</tr>
<tr>
<td><strong>Oil and gas fired heaters</strong></td>
<td>No</td>
<td>6m</td>
<td></td>
</tr>
<tr>
<td><strong>Oil supply pipes &amp; tanks</strong></td>
<td>No</td>
<td>6m</td>
<td></td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Security System maintenance</strong></td>
<td>No</td>
<td>6m</td>
<td></td>
</tr>
<tr>
<td><strong>Structure and Construction</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Floors, stairs and landings - Check for hazards</strong></td>
<td>No</td>
<td>1w</td>
<td></td>
</tr>
<tr>
<td><strong>Roof Coverings - Inspection</strong></td>
<td>No</td>
<td>1m</td>
<td></td>
</tr>
<tr>
<td><strong>Gutters, roof outlets, rain pipe, inspect and clear</strong></td>
<td>No</td>
<td>6m</td>
<td></td>
</tr>
</tbody>
</table>
The exact nature and type of data required in a management information system will vary depending upon individual property estates and the needs of a business or organisation. Some property managers, owners and landlords will require access to vary detailed information, which will be shared with others in the organisation. More senior personnel require only an overview, for example of the physical condition of their properties. The more detail required in a set of information, then the costlier it is to collect, keep it under constant review and updated. To illustrate this point, a European government decided to commission a national survey of the physical condition of state owned school buildings in 2012, in order to assess the cost of backlog repairs and to gather information to help shape a more strategic and planned approach to maintenance and improvement. The government department required evidence for the competitive bidding for funds against other departments and to ensure that money could be targeted at schools most in need. This enormous logistical task was subjected to competitive tender amongst building surveying/construction expert consultancies.

To ensure that this national building condition survey remained feasible and deliverable, the brief was confined to providing an overview of key building elements on a block basis for each school site. Each school was divided into physical blocks and a condition scoring system applied for example to the roof, external walls, heating and cooling system. Upon completion of the survey individual school managers had web access to the assessed investment needs of their buildings.

Compare this overview approach to the more comprehensive methodology adopted by previous governments, when surveyors and engineers collected data on a room by room basis internally and for each elevation externally. The database capacity requirements and time needed to conduct the survey and manage the data at this level of detail were considerably greater.

The range and type of data on physical condition of property typically required for management purposes includes:

- Addresses and unique property reference numbers
- Property types, age, form of construction and uses
Some information will only need to be collected once and will not change – base data such as original form of construction and age – whilst other information will require periodic updating, such as the condition codes applied to each element as they age and deteriorate over time. Consequently an initial survey to populate a database as a general role will take more time to complete than subsequent surveys, due to the capture of the base data.

A challenging specification requirement for maintenance management information systems is posed by property estates which are geographically dispersed and are of diverse ownership and construction. Agents managing commercial, industrial, retail and residential blocks use software with integrated property management, accounting and tax administration functionality. Each block or property under management will probably have a different layout, size, form of construction, maintenance liabilities and occupancy and the software has to be sufficiently flexible to reflect this diversity. Similarly a university campus site which has grown and developed over a period of time, will comprise a mix of building types with a wide range of uses. The physical condition, utilisation of space and functional suitability of each building will differ and consequently so will the demands made on the management information system. The more diverse the property estate then the more demanding it becomes on the software to cater for the information captured and the output required by users.

Many organisations – often with similar types of property estates – through the 1990’s and 2000’s embarked on ambitious plans to develop their own databases/systems or they chose to purchase modular based proprietary software. Both options proved to be costly, as the demands made by users changed and software and hardware rapidly evolved. Arguably many systems became too sophisticated and costly to support in terms of IT, administration and surveying resources. The market responded with the development of more flexible, less all embracing, lower cost web base solutions.
5.1.1 Information for maintenance planning

Once the maintenance policy framework is in place for an organisation, the next key stages are to prepare the maintenance programme and to secure funding. Such programmes are inevitably built on the basis of assumptions and forecasts relating to the physical condition of the property, future changes in regulations and standards, the cost of finance and many other factors.

The quantity and quality of information collected will help the building surveyor/construction expert to manage the risks inherent in forward planning. A reliable information base will ensure that budgeting for example can be reasonably predictable. The sources of information required for effective planning and programming based on the lifecycles of building elements are essentially:

- Building condition surveys (ideally conducted on a 5 year cycle)
- Annual inspections
- Defects and faults reported by users and occupants
- Ad hoc inspections e.g. defect investigations
- Servicing and maintenance recommended for building services and elements
- Meeting the inspections and tests set out in statutory regulations

Information from all these sources is captured in a management information system which nowadays is invariably a web based platform. The quantity and type of data gathered varies between business and organisations. In the case of a school, health clinic or small hospital site, clearly handling the flow of information will be less demanding than for a major national retailer with multiple, geographically scattered sites. What all organisations share, however, is a need for an information system – essentially a database – to manage the maintenance workload generated from their disparate sources. For large organisations the information has to be efficiently collected, collated and output for operational and strategic management purposes in larger organisations. In smaller organisations it is sufficient to formulate a five or ten year maintenance plan in a spreadsheet, on the basis of a building condition survey.

The role of information technology is a vital consideration in the way that business and organisations set up and deliver repair and maintenance services. Owners and landlords need to take a strategic view of how information systems, technology and communications can help deliver this service in tandem with the wider needs of the organisation, such as financial accounting. An ideal system
would be fully integrated and provide holistic information about occupancy, properties and finance, using mobile technology to facilitate ease of updating records. In practice data is often held in many different systems, databases and spreadsheets. The key to selecting the right system is to thoroughly analyse the functions that the landlord needs to meet and not to specifying new systems which are too sophisticated. The more sophisticated the system then the more complex the arrangements needed for handling inputting and updating the data. Two contrasting software packages are outlined below. Many other software packages are available such as the maintenance and real estate management products from Dutch developer Planon.

“Lifespan Housing” is a tool designed for strategic asset management and is a web based software system. The software allows users the flexibility to integrate all their asset information and interrogate data across all areas to simply and quickly produce the reports needed and to efficiently manage and forward plan the maintenance and improvement of the housing estate. Lifespan is intuitive, can be customised to suit each organisation’s requirements and has the flexibility to interface with existing housing management systems.

Like many other similar packages available in the market, Lifespan comes as a complete system with mobile data collection devices and comprises modules including: asset register; planned maintenance; property standards; statutory regulations; energy efficiency; cyclical maintenance; cost modelling and project management. Users can tailor the survey form and edit the built-in schedule of rates and life expectancy values in the planned maintenance module. A specific building element – type of cladding – can be added for example, or costs varied to suit regional differences. Once the database is populated, cost modelling and other tools allow users to forecast expenditure, analyse and compare plans and formulate programmes of work. Completed work and inspections are logged, there are standard reporting templates and complete flexibility in report structures and outputs.
Fig 5.1 Web based Lifespan software page layout
It is inconceivable now that any medium to large housing landlord could manage multi-site property assets without a database software system. Packages are also available to suit the smaller landlord end of the market.

Indeed the advent of software and electronic data collection in the 1990’s facilitated large scale property surveys, the capture and analysis of valuable maintenance information and the wider adoption of more efficient and effective planned maintenance techniques and practices.

“TES Foundation” is an operational management system specifically written for single site school premises. This low cost intuitive software helps managers plan inspections, servicing of plant and equipment; risk assessments; track repair requests, record and analyse trends, contract management and provides reports in various formats. Jobs can be marked as completed and the data refreshed with ease. Preformed templates allow users to schedule alerts and activities, such as when contracts are due for renewal. All associated maintenance documents are filed in the software, such as risk assessments, management plans, floor plans, asset register, supplier contracts and maintenance programmes.

Access to the software is available from a laptop, desktop PC, smart phone or mobile device. With this web based system school managers have the reassurance that important documents and data is stored off site as part of their business continuity or emergency plan.
Fig 5.2. Screen shot from TES Foundation software
5.1.2 Specific information for reactive maintenance

Reactive maintenance jobs are by their nature small scale, low value and they can occur in unpredictable locations. It is common practice within organisations that defects or problems are flagged or ordered on-line by individual building users and occupants. The repairs are specified and ordered, and then finance, contracts and performance have to be managed.

A target driven approach to managing repairs will have three priority categories for ordering and monitoring purposes: emergency (e.g. gas leak), urgent (e.g. loss of hot water) and routine repairs (e.g. replace door lock). Software is used for scheduling jobs, issuing work orders, monitoring progress, cost accounting, budgetary control and for monitoring the stock of materials. Reporting output then provides analysis of agreed key performance indicators for managing contractors and directly employed labour, together with financial data for internal accounting and a revised maintenance record for each property. Ideally the software for managing reactive maintenance interfaces with that used for planned maintenance to enable automatic updating of records. When for instance a roof covering is substantially repaired in a property, the life expectancy of this element is automatically extended in the property record within the asset management plan.

The system requirements for handling reactive maintenance data in a property estate comprising say 10,000 houses and apartments is clearly more demanding than that for a single school. Web based software is available to all managers to suit their needs and budgets (see case studies below).

5.1.3 Specific information for asset management

Information for planned maintenance is sourced from periodic building condition and compliance surveys, together with information on items such as:

- recommended plant and equipment servicing and maintenance requirements
- hazardous and harmful materials
- disabled adaptations
- energy efficiency measures
- improvements to specified standards
- contingency for major structural repairs
- securing and managing vacant property
The information which is systematically collected from property surveys – whether collected on mobile devices or by paper template – needs to record for each building element, the following attributes on repair and replacement:

• where it is
• what it is
• what condition it is in
• what, if anything needs to be done
• how much of it there is
• when does it need to be done

For the purposes of planned maintenance, information collected on the current physical condition and on anticipated repairs and replacements, needs to be combined with data on benchmarking standards and statutory compliance for analysis and reporting on needs and priorities.

The model below serves to illustrate the broad range and overlapping nature of information required for property asset management. Analysis of the data captured helps direct the manager to focusing on identifying priorities and achieving best value objectives in planning expenditure. For example replacing an inefficient type of boiler would improve the energy performance rating of a property, reduce the risk of system failure and reactive maintenance and meet higher standards imposed by statutory regulation.
Fig 5.3. Residential property information needs
A property estate comprising buildings of varying age, form of construction, size and physical condition, generates fluctuations in expenditure on major items of repair and maintenance. Longer term forecasts underpinned by regular and systematic surveys and inspections, provides information which enables managers to smooth out the annual workload and budget, avoid these fluctuations and this makes financial management and planning easier. Major items of work would typically include: repairs to roofs; pointing to walls; renewal of lifts or electrical rewiring.

5.1.4 Management reporting

Whilst having access to good quality information is a key requirement for delivering a repairs and maintenance service, it is important that the data collected is effectively used to improve the service delivered and reduce costs. The IT capability to interrogate data comprehensively and present management information to a high standard is constantly improving. No software, however, can compensate for poor quality or inaccurately input survey data.

Having collected the comprehensive base information illustrated in the model below, then reports can be generated which draw data for any level of detail required by managers. The apex in this triangle represents the top level overview or strategic level reporting normally required by senior management, whilst operational level reports are obtained from the detailed information signified at the base of the model.
A variety of reports can be produced by standard proprietary software according to selected criteria and to suit the different purposes of managers throughout a business or organisation. The finance department may only be interested in summary cost figures, whereas the maintenance department will demand detailed and costed repair schedules.

In planning maintenance workloads, managers need to consider and evaluate all available options open to them when forecasting expenditure and setting budgets. Property asset management software commonly incorporate a module for modelling future costs. The software enables scenarios to be composed by grouping properties and planned work to establish the most cost effective fit between available funds and identified maintenance need. The financial and programme implications of different scenarios can be modelled and compared prior to choosing the optimum strategy.

Standard reports for planned maintenance, available in all software packages, will provide itemised works with budget costs accorded to specified properties over a chosen timescale. Building surveyors/construction experts then apply their expertise and judgement in compiling the programme of work, perhaps by grouping appropriate repairs and replacements to undertake work off the
same scaffold or benefit from economies of scale. Intuitively written software permits users to select, filter and group functions when reporting.

5.1.5 Standardisation and data sources

The primary objective of property maintenance is to maximise the physical life of existing buildings. This is achieved through a maintenance practice designed to anticipate all of the maintenance requirements through the whole of the extended physical life of a building. This whole life emphasis represented a significant shift in management approach from the traditional one which was wholly response orientated, to one which is based on the need to plan and prepare for the inevitable natural end of life of building elements and components, which are shorter than that for the structure of the property.

The introduction of this planned approach to maintenance relied upon management information systems designed to provide medium to long term projections of likely maintenance demand. The need to predict events in the future life of a property – rather than simply wait for them to happen – was a key driver in the development of property asset information systems, which were capable of providing detailed analysis of the property portfolio.

Two important techniques that underpin property asset information systems is that of whole life costing and coding systems of building elements to standardise data collection and analysis. There are different coding systems in common use and reference has been made in Chapter 2 to this aspect of survey methodology.

Where the property portfolio comprises large numbers of properties of a similar type, this feature lends itself to standardising data collection by tablet, PDA or mobile device, using software containing drop down multi-choice questions. The survey template within the software is designed for ease of use and speedy data collection. In this way comprehensive information addressing the items listed above – see specific information for asset management - on repair and replacement can be conveniently collected, based on a visual inspection of a property, for all principal and other specified building elements.

Where the property portfolio is mixed in terms of age, type, forms of construction and size, then data collection electronically during site surveys becomes more problematic. Much depends on the level of information required and the extent to which narrative comment needs to be captured. For example
commercial buildings, local town halls and leisure centres will each have multiple roofs and external walls, built using a variety of materials and possibly altered and extended at different times. The choice of building material and repair options is much greater. Accurately recording all the information on repairs and replacements from pre-selected menu choices becomes more difficult without having to resort to narrative. Notwithstanding these limitations, there are many software packages available for carrying out building condition, statutory compliance and fitness for purpose surveys which can be used for all types of property. The costs and benefits of using these data collection packages over more traditional paper based methods would need to be assessed by each property and facility manager according to their specific needs.

5.2 ASSET MANAGEMENT SYSTEMS

The needs of software users differ between owners, occupiers or managing agents. Web access solutions allow all parties to log on to the internet and access a range of property and financial information, which facilitates greater transparency, clearer communication and more effective property management. Web access enables owners, agents and tenants to view, update and add property maintenance events. Tenants and building occupants can use a secure login to view property-related documents, their service charge expenditure and details of current maintenance work on their property. This facility is particularly beneficial where landlords and agents operate over a large geographical area and from a network of offices.

Web based software is now the preferred platform for property asset management systems and there are many proprietary packages available to suit large and small businesses and organisations. There is no longer any justification for an organisation to develop, commission and maintain expensive bespoke systems in-house. It is no longer necessary to purchase the software as there are “software as a service” options now using cloud technology. Users pay an annual licence fee instead of having to fund the purchase of the software, which should especially benefit owners and managers of smaller property estates. The web based platform provides unlimited access to users – anywhere, anytime, anyone – which particularly benefits organisations with geographically dispersed and large property holdings. Software is now commonly compatible with Microsoft, Apple and Android.
products and can be accessed by smartphone, tablet, personal digital assistant (PDA), laptop or PC to meet user expectations on convenience and ease of use. Consequently all authorised members of an organisation can access and use the data wherever they are based, together with third party contractors and other nominated bodies.

A typical system will comprise data collection software for mobile devices and the database software (SQL Server). Standard data collection software has a user defined survey design function. Paper based methods for collecting information are still used during building condition surveys although these have been largely superseded by hand held electronic systems.

During the collection of survey data it is important that the professional insight and judgement of the surveyor is fully recorded at the time of the inspection. One of the criticisms levelled during the progressive move from paper based to electronic methods, was that because of the need to codify options on the hand held template, this would restrict surveyors to selecting an answer which may not fully describe the actual situation encountered at the property. Furthermore it was argued that the surveyor did not have the facility on the PDA to review the input data easily upon completion of a survey which they had been able to do traditionally with paper based methods.
### Table 5.2. Advantages and disadvantages of paper based over hand held data collection methods

<table>
<thead>
<tr>
<th>Performance criteria</th>
<th>Paper based forms</th>
<th>Electronic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting up survey template</td>
<td>Speed</td>
<td>Knowledge of software to be used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thorough testing before site use</td>
</tr>
<tr>
<td></td>
<td>Layout adjustments easy</td>
<td>Dependent on user defined capabilities</td>
</tr>
<tr>
<td>Ease of use</td>
<td>Flexible to navigate through questions</td>
<td>Larger displays enable easier navigation</td>
</tr>
<tr>
<td></td>
<td>Training required</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Need to download and reference photographs accurately</td>
<td>Photographs linked to property reference number</td>
</tr>
<tr>
<td>Narrative records</td>
<td>Easy to insert comments and sketches</td>
<td>Free text now easier to insert</td>
</tr>
<tr>
<td></td>
<td>Handwriting difficult to read</td>
<td></td>
</tr>
<tr>
<td>Validation</td>
<td>Manual checks easy</td>
<td>Routine checks built in to spot omissions &amp; prior to saving</td>
</tr>
<tr>
<td>Hardware issues</td>
<td>Difficulties in wet weather</td>
<td>Battery life</td>
</tr>
<tr>
<td></td>
<td>Data transfer if not online</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Security from theft</td>
<td></td>
</tr>
<tr>
<td>Downloading data</td>
<td>Typing time and errors</td>
<td>Speed and ease</td>
</tr>
<tr>
<td></td>
<td>Updating from previous surveys easy</td>
<td></td>
</tr>
<tr>
<td>Costs</td>
<td>Printing and inputting</td>
<td>Hardware &amp; software</td>
</tr>
</tbody>
</table>

Whichever system is adopted on site, the method of recording information must be efficient, accurate and flexible enough to facilitate successful surveys of all types of buildings. Electronic data capture has been standard practice in asset management surveys of residential properties since the mid-1990s. The adaptation of hand held software for surveys of property estates with larger and more complex buildings has been resisted in some quarters until relatively recently because of the inflexibility in the design of the survey template.

Surveyors conduct inspections in different ways; some start internally on the top floor and work down whilst others commence externally, and the hand held device software has to be flexible enough to accommodate the different preferences of users. Furthermore the key principle is that the maintenance data
must not be compromised when it is captured during a survey just to fit with the constraints set by the choices in the drop down boxes in the software

5.2.1 Asset management software

The available software in the market comes with standard modules for capturing planned maintenance; compliance with building performance standards and statutory regulations; energy efficiency and sustainable maintenance; equipment servicing and inspection; functional suitability, space utilisation and other requirements. A wide range of additional standard functions also include: cloning and extrapolation of survey data; project management; sustainability or carbon footprint modelling; equipment and appliance asset registers; investment cost forecasting and modelling, and integration and interfacing with other systems and software such as geographical information systems.

Whilst large businesses and organisations aspire to having all their information for asset management and planned maintenance in one database, most will in practice have information held on a combination of stand-alone systems, databases and spreadsheets. Moving towards a fully integrated approach cross business financial, accounting and other software requires strategic direction.

Maintenance management has suffered in the past because of the lack of access to comprehensive records of construction, alterations and past maintenance. Information technology now facilitates storage and easy access to plans, construction details, manuals, asset register and risk assessments in a variety of formats. All this information is stored in the asset management software and is of immense value for operational planning purposes.

5.2.2 CAFM (computer-aided facilities management) and property management software

CAFM (computer-aided facilities management) software originated in the 1980’s to serve the needs of facilities and estates management in: strategic planning; space planning and management; scheduling preventative maintenance; managing business continuity; property and asset management. BIM integration is available with products such as Autodesk Revit.
Traditionally the manager has scanned paper floor plans or imported CAD files for use within CAFM. The electronic floor plans are then used as backdrops to create "poly-lines" (closed loops composed of line and arc segments) to define an area and to identify room numbers to name that area. This is a labour intensive process which has been addressed by companies such as Autodesk.

A range of large and small software suppliers are available, typically providing modules various described as: space management; strategic estate planning; asset management; property management; project and facility management.

Asset management software enables users to track multiple classes of assets – office equipment, furniture, lab equipment – and assets can be linked to CAD symbols on floor plans for location, ownership and access to product information. Of particular interest to building surveyors/construction experts are the asset management applications which can integrate with other software, barcodes or enterprise resource planning (ERP) systems, making asset tracking more robust. Tracking and locating assets on floor plans and linking information on ownership, serial numbers, manufacturers servicing requirements is a very useful function.

A further valuable feature of CAFM is preventive maintenance scheduling and issuing of work orders. Inventories and a detailed history of building equipment and their related maintenance requirements and cost history can be stored. The software generates reminders for routine tasks such as six month servicing and inspection of HVAC, mechanical and electrical equipment and automatically creates a maintenance work order in the system.

CAFM systems are used to ensure assets are inspected, tested and certified in accordance with statutory and corporate regulations and procedures. Audit trails are available for inspection and a variety of management reports can be generated by the software.

A computerised maintenance management (CMMS) software package maintains a database of information about an organization’s maintenance operations. This information is intended to help maintenance workers undertake their jobs more effectively (for example, determining which plant and equipment requires maintenance and which store rooms contain the spare parts they need) and to help management make informed decisions (for example, calculating the cost of machine breakdown repair versus
preventive maintenance for each machine, possibly leading to better allocation of resources). CMMS data may also be used to verify regulatory compliance

Various dedicated property management systems have been in use for some time. Most systems now favour web and cloud technology and offer their software to clients using a software-as-a-service model. The software varies by interface (online/cloud based/desk top), operating system (Windows/Mac/Linux and Mobile) and cost.

Building surveyor/construction expert will expect the following functionality from property management software:

- Record and track any type of maintenance activity for properties such as repairs or gas inspections.
- Track the maintenance jobs to completion, recording key details such as materials used, labour costs and attach any document or file to a job such as gas certificates or tenant inventory inspections.
- Automatically produce job sheets, purchase orders and reports on maintenance activity
- Easily communication with your contractors via email or instant message
- Generate various landlord reports
- Record key supplier details such as contact details, telephone numbers and email address
- Look-up suppliers either alphabetically or by supplier type (e.g. decorator)
- Produce supplier payment history reports

5.2.3 Building Information Modeling (BIM)

It is internationally recognised that Building Information Modeling (BIM) technologies, processes and collaborative behaviours will unlock new more efficient ways of working at all stages of the project life-cycle. Virtual modelling offers opportunities for improved understanding of the entire life cycle of a building and increases the predictability of asset performance. BIM will be of immense value in the care of and maintenance of buildings.

BIM enables the design and build team to construct a virtual building where the designs are in 3D and integrated with the mechanical and electrical design, civil and structural engineering and cost control so that every member of the team are
As a BIM model comprises representations of the actual component parts used in the assembly of a building, the building surveyor/construction expert will be able to simulate its deconstruction, where for example a defect is under investigation or replacement elements are being planned. Envisage the situation where in a high rise commercial complex, rainwater ingress is being traced through external wall cladding panels with hidden fixings. Personnel can consult the 3D model to reverse the assembly process and understand how the rainwater could progress, assess the likely extent of consequential damage to hidden components and plan how repairs and replacements might be executed.

BIM which links with an asset management software can retrieve information quickly on equipment data, service manuals, equipment performance, warranties, manufacturer contacts, and video demonstrating installation
and maintenance procedures of plant and equipment, to enable technicians to review procedures before carrying out maintenance.

The BIM model contains information on geometry, spatial relationships, quantities and the physical properties of building components, but could also link interactively to current manufacturers’ guidance on repair and replacement methods. Linking BIM with geographical information systems, building managements systems and other technologies offers exciting prospects for surveys/construction experts, albeit of large commercial and corporate property portfolios in the short term whilst application costs remain high. The majority of building managers with smaller and less valuable portfolios may have to wait 5 years before BIM is scaled down and becomes established for all medium sized projects.
Manchester City Council town hall extension and Central Library have been extensively remodelled and refurbished in a £100m project completed in 2013. The scheme was designed by two architectural practices, Central Library by Ryder Architecture and the Extension by Ian Simpson Architects, with Laing O’Rourke as main contractor. The core team of approximately 100, including client and key suppliers, worked in an open plan project office opposite the site. The process was apparently fraught at times with conflicting demands from the various members of the design team. Efficiencies through the design process were secured using BIM. The biggest single gain claimed was the coordination of components using clash detection software, combined with a virtual build function, which meant mistakes were identified before work commenced on site. The use of BIM increased the attention given to the selection of components at the earliest stage in the design process. The project manager observed that BIM provided the perfect opportunity for components to be assessed on all the usual criteria, but particularly on their durability in use.

Fig 5.5. Construction project using BIM
The information that is developed and collected during the design and the construction of a building is uniquely important to the team that is responsible for maintenance and operation. This data, however, is frequently inadequately stored and this creates an ineffective, costly, and disorganized information system. BIM facilitates the exchange of information with building managers throughout the life of a building to overcome this problem.

Further beneficial applications of BIM for facility management include: improved space management; more efficient maintenance programming with access to asset registers and online servicing data; effective retrofits and renovations and enhancing life cycle management. The room and area information in BIM models furthermore provides the foundation for good space management. A "living" BIM model provides an easier means of representing three-dimensional space within a building to assist in planning alterations. By incorporating data on life expectancy and replacement costs in BIM models, owners and managers can better appreciate and understand the benefits of investing in materials and systems that may cost more initially but have a better payback over the life of the building.

Research from the United States suggests that the facility management industry is reluctant to invest in BIM for the following reasons: unwillingness to change traditional processes; cost; lack of awareness and understanding of benefits; lack of experienced personnel and resources, and concerns about updating data. The latter point refers to the fact that the numerous building systems in a property require different software for updating and software that can edit and navigate the entire model still does not exist.

'Software as a Service' (SAAS) cloud-based solutions are now available which seek to extend the value of BIM throughout the lifecycle of the building, by integrating information and making it instantly available in the form of data-rich online models.
CHAPTER 6

CONSERVATION, SUSTAINABILITY AND ENERGY EFFICIENCY

6.1 PHILOSOPHY

Arguably the challenge of sustainably is probably the greatest long term issue facing the human race and it has profound implications for managing building pathology and property maintenance. The Bruntland Commission (1987) defined sustainability as, “meeting the needs of the present without compromising the ability of future generations to meet their own needs”. This definition was succinctly re-cast by Van Ree and Van Meel in 2007 (see chart below).

Fig 6.1. The sustainability challenge
The underlying principle of sustainability seeks to balance economic, environmental and social objectives by: protection of the environment; prudent use of scarce resources; promotion of access to services for the benefit of all and the production of a wealthy local economy.

Popular awareness of environmental conservation in its broadest sense and consciousness of global depletion of resources including oil, gas and natural habitats was significantly raised during the 1960s. This led to governmental policy changes in the reinforcement of conservation and the protection of the historical and architectural built environment, and to reinvestment in the older neighbourhoods of cities.

The background to global warming and the concept of sustainability, however, can be traced back to the nineteenth century with the discovery that carbon dioxide levels were linked to global warming. The first world climate conference was held in 1979. Subsequent events and inter-government meetings have taken place in:

- 1988 Intergovernmental Panel on climate change (IPCC established)
- 1992 IPCC Second Report (referred to discernible human influence)
- 1995 Kyoto Protocol (entered into force 2005)
- 1997 Third report (contains new and stronger evidence)
- 2002 World Earth Summit
- 2007 G8 Summit Helligendamm United Nations Framework Convention on Climate Change (UNFCCC), Vienna
- 2007 United Nations Climate Change Conference, Bali
- 2008 United Nations Framework Convention on Climate Change (UNFCCC), Poznan
- 2009 15th UNFCCC Conference of the Parties, Copenhagen
- 2010/31/EU Directive

Within the European Union, individual national governments produced their own approaches to environmental regulation within this framework. The methods adopted to regulate energy performance of buildings and the development of policy instruments for sustainability generally, varies between member states.
In parallel with this governmental action, various agencies and organisations have introduced voluntary frameworks and tools to enable companies and organisations to measure and control environmental performance management (see below). ISO 14001 for example - first introduced in 1996 and revised in 2004 – is an internationally accepted standard that defines the requirement for establishing, implementing and operating an environmental management system. This standard identifies the need to define environmental policy before as a prelude to pursuing an action plan and measuring performance management. Some of the leading initiatives in environmental performance management are:

- EMAS (Eco-Management and Audit Scheme) is a European-wide voluntary scheme
- UNEP (United Nations Environment Programme) has supported the development of a Common Carbon Metric, which is a universal method of measuring the carbon footprint of a building on a consistent and comparable basis
- LEED (Leadership in Energy and Environmental Design) launched in 1998 by the US Green Building Council, is an internationally recognised green building certification system
- Green Star a scheme launched in Australia in 2003 as an environmental self-assessment rating system to evaluate environmental design and construction of buildings
- BREEAM (Building Research Establishment Environmental Assessment Method) launched in 1990 in the UK for environmental assessment and sustainable building design

The European Union Directives which have been issued provide a framework for member states to the take action on reducing environmental action. The EU Emission Trading Scheme (2005) aimed to encourage large emitters of carbon dioxide and other greenhouse gases to reduce emissions on a “Cap and trade” basis. The WEEE Directive in 2003 (Waste Electrical and Electronic Equipment) sought to increase the re-use and recycling of these goods and materials and thus minimise environmental impact. In December 2008 European Union leaders approved a comprehensive package of emission cutting measures. This plan aims to reduce greenhouse gases by at least 20% by 2020 (compared with 1990 levels), raise the market share for renewable energy
to 20% and reduce overall energy consumption by 20% (compared with projected trends).

Within this regulatory context of environmental protection, building owners and users increasingly seek improved sustainability performance from their buildings. Individual governments continue to modify their own land use planning, building standards and codes for new construction and refurbishment, to meet the higher expectations driven by climate change. Often these are supplemented by aspirational targets and standards for sustainable building covering thermal efficiency and conservation of water resources. Governments are increasingly using financial and tax incentives to encourage improvements in energy efficiency and the generation of energy from renewable and low carbon sources to reinforce regulatory codes and best practice in design and specification.

Addressing sustainability issues increasingly impinges upon all stages of the property lifecycle: greenfield development and estate management; land use planning; new construction; occupation and use (including refurbishment and maintenance) and the demolition/remediation of the land. The key issues to be addressed at different stages during the property lifecycle encompass: cultural heritage; drainage and flooding; energy efficiency; health, safety and wellbeing; pollution and waste; travel and transport; water use and recycling; biodiversity; land use and the use of materials. This has resulted in a fundamental shift in emphasis in building maintenance management. A deeper and broader knowledge of building performance is now necessary when judged against the sustainability criteria outlined above.

### 6.2 HERITAGE PROTECTION AND CONSERVATION

Heritage built assets are irreplaceable resources and all governments have legal frameworks for building conservation. Strategies to conserve and enhance the historic environment seek to put individual buildings and areas of towns and villages to viable use, consistent with their conservation, and to draw on the wider social, cultural, economic and environmental benefits that conservation can bring. Conservation status is normally bestowed on an area or neighbourhood because of its special architectural or historic interest. Any new building within such a designated area should ideally contribute to and
enhance the local environment through a design which is in harmony with the
surrounding historic landscape.

The sustainability or green agenda now imposes higher design standards
in refurbishment. These standards include improved energy performance,
reduced environmental impact and healthy, comfortable and safe environments,
which offer higher occupant satisfaction and productivity. Technological
improvements in building materials and in renewable energy generation can
make a positive contribution in heritage protection and conservation.

6.3 SUSTAINABLE DESIGN
AND CONSTRUCTION

During the lifetime of a building, a significant quantity of raw material and
other natural resources are consumed and tonnes of waste and emissions are
produced. A sustainable approach to design, construction, building occupation
and maintenance attempts to address these issues.

The concept of embedded energy has gained ground over recent years in this
context. In order to reduce the environmental impact of buildings, the energy
used during the construction as well as that consumed during occupation have
to be reduced. Embodied energy is the total quantity of primary energy
consumed during the lifetime of the building. Included in this calculation is the
energy used in manufacture, transportation, construction, building use and
ultimate demolition. Specifying the use of recycled materials, avoiding building
systems with high maintenance requirements and adopting measures to reduce
the incorporation of embodied energy are some of the ways that building
surveyors/construction experts can assist in reducing consumption.
The increasing recognition of embodied energy in buildings, together with the
continual rise in energy costs, is helping to drive innovation in the manufacture
of building products. One example is the development of a new process for the
manufacture of cement, which uses significantly less fossil fuel as a primary
source of energy. A second example would be the increasing practice
of procuring building materials through local suppliers for retrofit projects
and thereby minimising transportation and reducing the carbon footprint.

Changes in design, specification, construction methods and in facility
management all impact on the management of maintenance and building
pathology. Whilst this impact is particularly evident in the area of energy efficiency, it is nonetheless felt in the implementation of sustainable measures generally, including rainwater and grey water recycling, waste and pollution reduction.

Sustainable design and construction is having an impact on the management of maintenance and building pathology in a number of ways. Before demonstrating how this impact will be felt, it is important to understand what sustainable design and construction entails.

Sustainability increasingly addresses a wide range of issues in attempting to reduce environmental impact, whether it be for new build or refurbishment and retrofit.

- Spatial planning: reduced travel and suitable density of development
- Environmental design strategies: passive design, maximising daylight, building orientation, (north facing rooms have lower solar heat gain), shelter and shade (roof overhangs to enable low solar heat gain in summer for south facing rooms, and higher useful winter solar heat gain), natural ventilation
- Energy and carbon dioxide emissions
- Building materials specification: reused materials and responsible sourcing
- Waste, recycling and pollution
- Water conservation and harvesting: sustainable drainage systems
- Waste water recycling
- Surface water run-off and flood risk
- Ecology and biodiversity

The changes in design and construction that these initiatives are generating has an impact on maintenance and building pathology. This requires knowledge and understanding of how new and existing buildings perform when new materials, building techniques and technologies are incorporated. This can best be illustrated through a series of examples.

Building surveyors/construction experts perhaps more than ever need to involve facility managers in considering the maintenance implications of all materials, products and services proposed for development schemes in terms of:

- The potential to design out the need for maintenance through the judicious choice of materials e.g. solar control glass, heat reflective paints incorporating nanotechnology
• Provision of easy access for maintenance e.g. rooftop man-safe cable and harness systems
• Need for specialist knowledge e.g. combined heat and power systems; air pressurisation testing
• Installation and servicing e.g. solar panels. Inverters, heat pumps
• Maintenance e.g., green roof surface and drainage, sustainable drainage systems, air source heat pumps, solar panels, water harvesting and recycling plumbing and pumps
• Availability and cost of spare replacement parts e.g. LED light fittings
• Further potential to develop building management systems to monitor electrical and mechanical plant and equipment e.g. smart meters linked to BMS.
• Management of risk e.g. implications of failure and health and safety assessments

6.3 ENERGY EFFICIENCY

A key objective and component of sustainable construction, retrofit and maintenance is improved energy efficiency. In this context energy efficiency is taken to include reduced energy consumption during the occupation and use of buildings, together with the generation of renewable power and heat from low and zero carbon sources. Reduced energy consumption can be achieved by combined actions such as improved thermal performance of the building fabric; more efficient space heating and cooling, water heating and lighting, and by changing the behaviour of users and occupiers. Policy makers have been guided by the widely recognised priorities for sustainable action on energy which is illustrated below.
Fig 6.2. Energy efficiency hierarchy

Underpinning the improvements being achieved in energy efficiency and in reducing the carbon footprint of buildings, is the ability to accurately measure and monitor performance. Software tools are used for key performance measurement and for modelling energy use, carbon emissions and energy consumption costs in all types of buildings. The metrics used are kilograms/carbon dioxide (Kg/CO\textsubscript{2}) for carbon dioxide emission, kilowatt hours (kWh) for energy use and various rating systems devised to indicate and understand absolute and relative performance. As buildings differ in their built characteristics and occupancy, these ratings provide an indication of the improvement needs and potential to be fulfilled in individual properties.

Actual energy use or carbon emissions can be assessed using historical data to give a real measure of performance. Common ways of measuring what has happened in the past is to use data from energy bills, test data such as air
tightness, energy meters and temperature monitors. Modelling techniques on the other hand, can be used for predicting changes in performance, such as when evaluating options for sustainable retrofit. As there are a number of variables needed for example when predicting the energy consumption of an individual residential property, it would be difficult to estimate the exact use of energy accurately. However, if typical parameters are selected for internal temperature, occupancy patterns, building fabric performance, heating and cooling equipment efficiencies, then a reliable model could be generated for comparative purposes in assessing improvement potential in buildings.

A true measure of energy consumption and efficiency is usually made in kWh which may then be converted into cost (Euro), or tonnes of CO$_2$ for application as an environmental metric. Alternative measures have been developed to meet different needs. As the costs and CO$_2$ emissions vary for oil and gas when used as primary fuels, conversion factors are applied in order to compare performance. Profiles of energy consumption, cost and carbon footprint can thus be established by modelling or metering for individual and groups of buildings.

Thermal design is concerned with heat transfer processes that take place between a building, its surroundings and the external climate. The building design takes into account: building form and fabric; building services; the occupants and processes contained within the building, and the energy used for heating, cooling, ventilation and lighting. An individual’s thermal comfort is influenced by air temperature, air movement, relative humidity and the surrounding radiant environment. Architects and surveyors will make use of passive design features of a particular site, the form of the building, features of the fabric, together with active design parameters in the specification and installation of environmental services to meeting thermal design standards.

In southern European architects and designers seek shading and cooling solutions. Designers in Northern European countries are challenged with understanding how heat generated internally is lost and how this can be mitigated by air tightness measures (reducing leakage) and by improving insulation in the building fabric. This in turn requires knowledge of how the building fabric loses and gains heat and cool air, the mechanism of heat transfer, thermal bridging, ventilation and condensation.

A measure known as the “U value” (heat transfer coefficient) is used to measure energy lost by conduction through any material, given a specified temperature difference across the building fabric element. The “U value” is inversely proportional to the thermal resistivity of a material. This means that the more
resistant a material is to allowing heat to pass through it, the smaller the “U value”. The measure is a good comparator of the insulating properties of materials and it has become the de facto standard for measuring insulating properties for energy calculation purposes. The heat loss for individual building elements – floor, external walls and roof – can be calculated and summed together to determine heat loss through the building fabric as a whole. Building regulation codes use this measure as a benchmark standard.

The “U value” of a material is then a gauge on how well heat passes through the building fabric, the greater the resistance to heat the better the insulating value. The “U value” is generally used in the building and construction industry to specify assemblies of components which provide suitable insulation and energy efficiency value. This value is expressed in units of watts (W) per square metre/Kelvin (W/m²K) and relates to the amount of heat lost in watts (W) per square metre of material. Basically if a wall material has a U-Value of 1 W/m² K, for every degree of temperature difference between the inside and outside surface there would be 1 Watt of heat energy flowing through each metre squared of its surface. Consequently the lower the “U value” means less heat loss, better insulation and effective lower fuel bills.

This value is added to the calculation for ventilation heat loss to establish the total heat loss for the building envelope. Methods have been developed incorporating empirical correction factors – such as geographical location – to enable robust calculations to be made for application in boiler and cooling equipment sizing for example.

6.4 NATIONAL CALCULATION METHODOLOGY AND ENERGY CERTIFICATION

In accordance with the European Union Energy Performance of Buildings Directive 2008, member states have devised asset rating systems to comply with the National Calculation Methodology and energy performance certification. The calculation methods used by member states have been aligned with statutory building standards (regulations) for new construction, refurbishment and retrofit. In this calculation the actual performance of a building is measured against a notional high performance building. The process involves calculating
monthly demands for heat, ventilation, cooling, lighting and hot water, based on building geometry, construction and the proposed activities and use of the building. A calculation is made of the energy needed to meet the forecast demands using system types and efficiencies, and then converts the energy used into CO\textsubscript{2} emissions.

Energy performance certificates are generated by Government approved web based calculation software and a report proposing recommended improvement measures is generated. The software and reports containing recommended improvements differ between calculations for existing and new buildings and between housing and non-housing types.

The recommended improvements measures generated by the software typically include the materials and installations in the chart below.
### Energy efficiency measures

<table>
<thead>
<tr>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loft and flat roof insulation</td>
</tr>
<tr>
<td>Cavity and external wall insulation</td>
</tr>
<tr>
<td>Floor insulation</td>
</tr>
<tr>
<td>Hot water cylinder insulation</td>
</tr>
<tr>
<td>Door and window draught proofing</td>
</tr>
<tr>
<td>Low energy lights</td>
</tr>
<tr>
<td>Hot water cylinder thermostat</td>
</tr>
<tr>
<td>Heating controls for wet central heating system (boiler and radiators)</td>
</tr>
<tr>
<td>Heating controls for warm air system</td>
</tr>
<tr>
<td>Controls for air conditioning system</td>
</tr>
<tr>
<td>Upgrade air conditioning system</td>
</tr>
<tr>
<td>Upgrade boiler using the same fuel</td>
</tr>
<tr>
<td>Install a biomass boiler</td>
</tr>
<tr>
<td>Biomass room heater with boiler</td>
</tr>
<tr>
<td>New or replacement storage heaters</td>
</tr>
<tr>
<td>Replacement warm air unit</td>
</tr>
<tr>
<td>Solar water heater</td>
</tr>
<tr>
<td>Install double glazing and insulated doors</td>
</tr>
<tr>
<td>Install secondary glazing</td>
</tr>
<tr>
<td>Condensing oil boiler</td>
</tr>
<tr>
<td>Change heating to condensing gas boiler (keeping existing fuel type)</td>
</tr>
<tr>
<td>Change heating to condensing gas boiler (changing fuel type)</td>
</tr>
<tr>
<td>Photovoltaics</td>
</tr>
<tr>
<td>Biomass boiler</td>
</tr>
<tr>
<td>Air or ground source heat pump</td>
</tr>
<tr>
<td>Air or ground source heat pump with underfloor heating</td>
</tr>
<tr>
<td>Micro-CHP</td>
</tr>
<tr>
<td>Flue gas heat recovery</td>
</tr>
<tr>
<td>Waste water heat recovery</td>
</tr>
</tbody>
</table>

Fig 6.3 Energy efficiency improvement measures
There are many technologies that can contribute towards improving building performance – insulation, alternative heat and cooling sources, digital controls – but some remain underutilised, particularly in residential property when occupants receive poor instruction. Building occupants do not always behave efficiently and interact with these technologies in the way that designers expect. Consequently in addition to addressing building science issues, such as thermal bridging and the installation of micro-technologies, the interaction between homes and workplaces and their occupants has a major impact on energy use and demand, which in turn impacts on the supply system. Our growing reliance on workplace and consumer electrical and electronic goods increases energy demand. It is important to understand how people use their homes in order to secure maximum energy efficiency. Most people continue to be unaware of how much energy they use in the home and workplace, and research suggests that they are insufficiently interested. When attempting to influence people to become more energy efficient there are a number of barriers to be taken into account. These barriers include: affordability; lack of information; distrust in sources of information and energy suppliers and the adoption of new technologies which people have to learn to use.

Policy makers and managers rely on psychologists to explore ways in which to promote sustainable behaviours by consuming less, living in a way that imposes less of an environmental impact and in choosing technologies that can help reduce energy consumption. Psychologists are able to assist building surveyor/construction experts understand the different factors that influence how people behave. The influencing factors that exert pressure on us to act in certain ways include:

- Physical environment e.g. access to controls for cooling and heating systems
- Social norms e.g. people dress in accordance with fashion and not to suit environmental conditions within buildings
- Positive reinforcement e.g. behaviours that are rewarding are more likely to be repeated
- Use of prompts e.g. signs next to light switches
- Feedback e.g. monitoring actions with smart meters
- Education and awareness training
- Attitudes and value – personal, social and cultural
- Self-efficacy - an individual’s belief that it is within their power to effect a change or to perform an action
- Unconscious or habitual behaviours
One interesting consequence of understanding how people deal with the pressure to reduce energy consumption is known as the “rebound effect”, where overall energy savings are reduced when users offset some of the savings they achieve by changing behaviour. Research has demonstrated for example that people turn up the heat, keep the air conditioning on longer or take more showers when they feel they have reduced energy use through other ways.

Whist it may be difficult to change an individual’s mind about investing in energy saving measures and behaviours, it is possible to change the context in which people make decisions about this issue. Context change should be focused on: better awareness through information and education; innovative and cost effective incentives; and using trusted intermediaries – such as community groups – to support and reinforce energy saving decision making.

New solutions to retrofitting older existing homes in northern countries to reduce energy use include insulating solid masonry external walls. Insulation can either be applied externally or internally but specifiers of both methods need to understand the dynamics of reducing the U values of building elements, to make effective use of thermal mass, reduce the effects of thermal bridging, improve air tightness and energy efficient ventilation. Similarly with external walls constructed in cavity masonry, how the insulation is installed needs close attention to detail in-order to provide effective thermal resistance and avoid problems with interstitial condensation and the hidden and visible effects of dampness. Ventilating sub floor and roof voids, and the installation of vapour control layers are two preventative measures adopted by building surveyors/construction experts.

Airtightness forms a key part of controlling energy loss and is crucial to achieving a good standard of performance in the energy efficiency of the building fabric. Infiltration or the leakage of cool or hot air from buildings increases the heating or cooling load and hence increases carbon dioxide emissions. Exfiltration where warmed or cooled internal air leaks out of the building, is replaced by cool or warm air as appropriate to the climate and location, and also increases the air conditioning load. It follows that by reducing unwanted air leakage, adequate planned ventilation must be specified to maintain a comfortable internal environment. Positive input ventilation, mechanical extract, or mechanical ventilation with heat recovery are appropriate solutions in these circumstances.

PassivHaus represents a design standard that demonstrates how to keep buildings at a comfortable temperature without using any conventional space
heating or cooling, whether applied to new offices or to renovated apartment blocks (Passivhaus Institut 2013). The key elements to this exacting standard are: the building envelope comprising floor, wall and roof should be highly insulated; air leakage through unsealed joints is completely eliminated; a mechanical ventilation and heat recovery system is used; heat loss from poorly insulated points in windows, doors or the building envelope generally is eradicated, and heat loss through windows is minimised in winter and heat gain minimised in summer.

Traditional design features in southern European countries may offer some solutions to the construction industry in northern states faced with the challenges posed by climate change. To provide protection from solar gain, buildings cluster in high density developments and they are finished externally in light colours which reflect the heat. Architects and surveyors employ features such as balconies, brises soleil, overhangs, light shelves, louvres, shutters, awnings and soft landscaping to minimise the effects of the sun. Devices used to enhance natural daylight transmission, reduce glare and reduce energy consumption, include light scoops, sun pipes and bright external surfaces and reflectors.

Driven by the increasing cost of energy, fuel availability, energy generation and distribution inefficiencies and the need to tackle climate change, the development and installation of low carbon micro-generation and renewable technologies is progressing rapidly. The term micro-generation encompasses many forms of small scale electrical power and heat production which may take place at individual buildings or at a district or neighbourhood level; the aim being to reduce dependence on carbon intensive electricity delivered through a national grid. Some forms of micro-generation only produce electrical power or heat whilst combined heat and power produce heat as a by-product or as a main energy output. The technologies in common use are summarised in the table below.
### Table 6.1. Low carbon micro-generation and renewable technologies

<table>
<thead>
<tr>
<th>Technology type</th>
<th>Features</th>
<th>Physical requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass systems</td>
<td>Wood and other biological waste fuelled heating devices</td>
<td></td>
</tr>
<tr>
<td>Solar photovoltaic (PV) systems</td>
<td>Electricity production directly from solar cells</td>
<td>Unshaded roof of 15m2 facing south-east through to south-west</td>
</tr>
<tr>
<td>Solar hot water systems</td>
<td>Domestic hot water production directly from solar collectors</td>
<td>South facing roofs with tilt of 30-45° and space need for cylinder</td>
</tr>
<tr>
<td>Wind power systems</td>
<td>Electricity production from wind turbines</td>
<td>Visual intrusion; local wind speeds dependent on distance from trees and buildings, location and height</td>
</tr>
<tr>
<td>Ground source heat pumps</td>
<td>Heat collection from the ground using the refrigeration cycle</td>
<td>Forming boreholes 25m – 150m deep or trenches can be disruptive; dependant on geotechnical conditions; heat distribution by under floor or radiators</td>
</tr>
<tr>
<td>Air source heat pumps</td>
<td>Heat collection from the air using the refrigeration cycle</td>
<td></td>
</tr>
<tr>
<td>Absorption heat pumps</td>
<td>Heat collection / transfer from another fuel source (e.g. natural gas) using the refrigeration cycle</td>
<td></td>
</tr>
<tr>
<td>Small-scale hydroelectric systems</td>
<td>Electricity production from small water turbines</td>
<td>Water abstraction licence; hydro potential is very site specific</td>
</tr>
<tr>
<td>Micro combined heat and power (CHP) systems</td>
<td>Heat and electricity production using natural gas fuel (conventional boiler replacement)</td>
<td>Gas connection and flue installation necessary</td>
</tr>
<tr>
<td>Renewable combined heat and power (CHP) systems</td>
<td>Heat and electricity production using biogas fuel.</td>
<td>Wood fuel boilers larger than conventional alternatives; space for fuel storage needed</td>
</tr>
<tr>
<td>Fuel cells</td>
<td>Electricity and CHP production through chemical conversion of hydrogen rich fuel sources (natural gas, hydrogen, propane etc).</td>
<td></td>
</tr>
<tr>
<td>Energy from waste</td>
<td>Anaerobic digestion large and small scale applications available e.g. bio diesel from waste cooking oil</td>
<td>Concrete base and electrical connection</td>
</tr>
</tbody>
</table>

Each of these micro-generation technologies is being continually improved to meet demand for low and zero carbon development. The key factors to be considered when evaluating the mix for any given building or development, are the relative capital and carbon abatement costs, operating and maintenance costs and implications for users. The wider maintenance implications of choosing each of these types of technologies must be clearly
understood as they are being installed on an increasing scale. Some of these issues are set out below. All installations may require local statutory approval and landlord consent.

- Future maintenance inspections to ensure tree and shrub growth does not cause damage to installations above and below ground and that their continual growth does not cause shading.

- Solar PV panels must be positioned to avoid partial shading; securely installed without compromising or damaging the roof structure, coverings and membranes and accessible for cleaning.

- Solar water heating flat plate and evacuated tube collectors (panels) may have a pump and require maintenance every 3 -5 years; cylinders need maintenance and panels cleaned.

- Photovoltaic panels have an expected service life of 20-30 years; reliability and power output are equally important; inverter life 8-10 years and need to be accessible with data logging and communication to permit speedy diagnostics and system adjustments; crystalline-silicone PV modules degrade with time and moisture ingress may cause reduction in output; delamination of panels and electrical connections affect power output; system fine tuning, regular inspection and cleaning to be recommended.

- Wind turbines require annual maintenance checks on electrical and mechanical components such as gearboxes and generators and may require painting.

- Micro combined heat and power (CHP) will need annual servicing and maintenance.

- Heat pumps have outdoor heat exchanger, compressor and fan to service and replace, whilst the indoor unit has a heat exchanger, fan and possibly a compressor to reverse the heat pump for cooling; good quality installation and appropriate controls essential to ensure good operation and financial savings; consider also the security of wall mounted air source pumps.

- Light fittings and controls: high efficiency lamps and luminaries; motion passive infrared and daylight sensing controls.
Supplying locally generated electricity direct to local consumers can avoid transmission and distribution losses that occur when electricity is supplied from central power stations. Equally the potential of supplying combined heat and power to individual buildings, neighbourhoods or groups of buildings offers enormous environmental and cost benefits. The maintenance and servicing implications of large scale adoption of these technologies should not be underestimated as building owners take control of the supply of power, heat and cooling to their properties.

Installations in new and retrofitted buildings for rainwater harvesting, re-cycling grey water and sustainable drainage systems provide further challenges for the building surveyor/construction expert in maintenance management. Rainwater may be captured at roof level or treated grey water – after bathing, washing or laundry – used for toilet flushing and irrigation, which will require internal pipework extending down from the roof or routed from bathrooms and toilets, together with storage tanks with pumps. These plumbing fittings and underground tanks should be well designed and installed to avoid the possibility of leaks and the consequential damage this can give rise to.

Water efficiency devices to reduce consumption are in common use and include efficient shower heads, low or dual flush toilets, flow restrictors and taps. Effluent discharged as sewage – referred to as black water - can be treated on site and this reduces the load on local water treatment works. When investigating the feasibility of black water treatment for a business park or housing development, factors such as cost, space requirements, infrastructure, treatment and recycling of sludge and water, maintenance of water quality and ecological sensitivity have to be considered. It is essential to maintain and repair rainwater, grey and black water systems effectively if they are to perform to design standards and to minimise health and safety hazards.

Sustainable drainage systems (SuDS) are designed to control surface rainwater run-off close to where it falls and to mimic natural drainage as closely as possible. Examples of SuDS include: basins and ponds; infiltration spaces or soakaways; and the use of permeable surfaces such as gravel or permeable paving. Surface water run-off in built-up areas tends to flow rapidly into the sewer system and this places a burden on the sewerage network and increases flood risk downstream as piped systems have limited capacity. SuDS help prevent this by using natural features that slow down the rate that water drains away thereby reducing the amount of surface run-off entering into sewers. Most conventional drainage infrastructure is out of sight but nevertheless should
be subject to planned maintenance. Features such as inlets, outlets, storage structures, silt traps, interceptors, flow control devices, headwalls, low flow channels and overland flood routes all require scheduled maintenance.

Adapting buildings for climate change will require design and operational solutions to reduce unnecessary heat gains, make effective use of thermal mass, appropriate ventilation strategies and active cooling, and be capable of future adaptation. Mitigation and improvement measures will include the planting of trees, shrubs and green space for shade and natural cooling through evapotranspiration; green roofs to reduce surface temperature; flood resilience and reduction adaptations and fittings.

Flooding can occur from rivers, sea, land, groundwater, sewers and drainage channels. Flood resilient buildings are designed to reduce the consequences of flooding, facilitate the speed recovery from its effects and help prevent consequent damage to the structure and fabric. Specific resilient measures would include: raising floor levels above that of flood defences; use of temporary barriers to prevent ingress of water; choice of low permeability materials and avoidance of timber construction and cavity walls in vulnerable positions; flood resistant linings such as ceramic tiling and hydraulic lime; non-porous insulation; concrete ground floors; locating electrical, gas and telecoms services and equipment above designed flood level; fitting one way valves on drainage systems, and maintaining flood warning systems.

One further environmental field in which building surveyors/construction experts need to keep abreast of changes is that of waste reduction and recycling. Waste management aims to minimise unused materials, off cuts and damaged products ending up in landfill and to crush and reuse aggregates and demolition waste. Local construction waste companies provide segregated containers, collection and recycling services. Web based directories of sustainable products and building materials provide specification and procurement guidance. Achieving lower costs continually drives construction companies to act smarter in optimising ordering, delivery and storage of materials, but the taxation of waste provides added motivation to economise.

Arguably there is now a greater onus on building surveyor/construction expert to liaise with the facility manager to fully understand the current maintenance issues presented by existing buildings and to identify potential problem areas that require improvement prior to major maintenance, retrofitting or renovation. Innovation in sustainable design and construction requires that the building surveyor keep abreast with policy, regulatory and technological developments.
CHAPTER 7

CASE STUDIES

7.1 “TRAINREBUILD” - BELGIUM

“Trainrebuild - Training for Rebuilding Europe” is a partnership of representative groups of networks and organizations, which addresses the training needs for retrofitting and financing energy efficiency in buildings. The project has addressed the demand side of the whole value chain of the building sector, is supported by eleven organizations across Europe (www.trainrebuild.eu) and co-ordinated by European Partners for the Environment www.epe.be. Brussels based EPE provides expertise in the field of the value chain management as knowledge transfer manager and as an interdisciplinary broker for innovation.

The context for this initiative has been the Energy Performance of Buildings Directive, which requires member States must ensure that by 2021 at the latest, all new buildings are to be nearly zero-energy. Working towards this goal of reducing the energy dependency of buildings, requires new thinking in land/property use planning and construction practices, particularly with respect to existing properties. Member States are obliged to develop by 2014 a long-term strategy for mobilising investment in the renovation and retrofit of their national building stock. The public sector within each State should act as a role model on energy efficient retrofit.

In April 2013 for example, the Spanish Government (Buletin 2013 Royal Decree 233/2013 Ministry of Development) introduced an initiative to promote - in part by grant aid - the maintenance and upkeep of housing blocks and condominiums. This policy aims to provide a broad framework for the recovery of the construction sector, generating employment and improving energy efficiency in line with the requirements arising from EU directives. Reference is made in the Buletin to improving the quality of existing buildings.
and in particular to addressing energy efficiency, accessibility, suitability for the collection of waste and conservation.

The Energy Performance of Buildings EPBD (2010/31/EU) calls for more information and training to assist property owners and their advisors with the introduction of more stringent building regulations, codes and construction standards. There is widespread recognition that the complexity of retrofit work, lack of knowledge on cost effective strategies and lack of information on accessing available funding schemes help deter property owners from taking action to improve energy efficiency.

The key actions and benefits arising from “Trainrebuild” have been: training property owners and local authorities in energy efficiency when retrofitting buildings, and upgrading capacity and improving the skill based provided to EU public and private building owners, aimed at improving the energy efficiency of the existing building stock.

Since 2010 the project has sought to design a comprehensive strategy to generate a change in thinking amongst public and private housing owners about the link between energy efficiency and capital and rental property values. A second principal objective has been to encourage retrofitting across a wide range of residential buildings.

The project has targeted staff of the national associations representing property owners, individual owners of all types of buildings and local authority officials. “Trainrebuild” has delivered training toolkits in eleven priority countries across the European Union. Other impressive results include: providing assistance on intelligent energy solutions to 500,000 property owners; the dissemination to 1250 local authorities of information about the training toolkits; eleven national action plans and two European action plans (one for property owners and one for local authorities) aimed at scaling up renovation in the EU in accordance with the Energy Efficiency Directive requirements. One further achievement has been that eleven associations of property owners have voluntarily committed to promoting energy efficient renovation amongst their communities, including encouraging collaboration amongst groups of owners in seeking retrofit opportunities and solutions.

Laboratories were organised within the framework of the project through multi-stakeholder and bilateral meetings to build capacity amongst building professionals, local authorities and financiers. Architects, construction experts and surveyors contributed knowledge of best practice in incentives, legislation
and technologies, which fed into the technical content of the training package
and toolkit for property owners. The laboratory for local authority staff
highlighted potential bottlenecks and potential improvements in administrative
processes. The dialogue with banks sought to maximise their participation
in support of training programmes, encourage more financial institutions
to serve as intermediaries for public funded projects and to leverage greater
private financing of for public works programmes.

National adaptations of the toolkits were produced for building professional,
local authorities and financiers as experience, practice and capacity was found
to vary considerably between Member States. The laboratory reviewing
financial mechanisms concluded that an implicit reason behind the reluctance
of banks to offer longer-term financing on energy efficiency revolves round the
lack of confidence in the stability of property values in many regions of Europe.
A similar lack of confidence was found to exist in supporting current energy
efficiency technologies. Banks are unwilling to commit to finance
to technologies that may become outdated within the payback period and
longer payback periods means less confidence being placed in the technologies.
Insufficient demand from property owners and a lack of perceived coherence
in existing public policies and financial schemes for retrofitting were also cited
as barriers to increased take up by owners.

Existing residential buildings are major emitters of carbon and require
significant reductions to meet EU 2020 targets. A lack of insulation, inefficient
heating and cooling systems and other factors result in typical homes using
excessive amounts of energy necessary to achieve acceptable comfort and
convenience standards. Consequently the training toolkit for property owners
included comprehensive ideas on energy efficient and renewable technology
measures that home owners could adopt, together with detailed guidance
on average costs, savings, payback periods and disruption/maintenance issues.
The specific needs of multi-family buildings were addressed to enable co-
ownership associations and their boards to inform co-owners of the issues and
resources available to enable them to tackle energy efficiency improvements
collectively.

The training toolkit for owners addressed 30 topics in information papers
on energy efficiency and renewable energy measures. A payback spreadsheet
template was included in the toolkit to assist owners evaluate the optimum
efficiency, investment and savings derived from a number of retrofitting
measures. The aims of the training package were to provide owners with the
means to help them decide which are the most appropriate measures for their
circumstances, and to understand how to negotiate the practical obstacles to implementing the right solution for them.

Financial guidance included information on EU wide funds such as ELENA and JESSICA as well Member State initiatives like Grenelle de L’environnement in France. ELENA (European Local ENergy Assistance) is run by the European Investment Bank and is funded through the European Commission’s Intelligent Energy-Europe programme. JESSICA (Joint European Support for Sustainable Investment in City Areas) is an initiative of the European Commission developed in co-operation with the European Investment Bank (EIB) and the Council of Europe Development Bank (CEB). This programme supports sustainable urban development and regeneration through financial engineering mechanisms.

The toolkit produced for local authority staff included modules on: poly and legislation; financing energy efficiency in buildings; technologies and project implementation; good practice examples and citizen awareness raising campaigns. Detailed guidance was produced on designing, implementing and funding successful campaigns to provide the public with balanced and objective information to address problems and find alternative solutions.
“Trainrebuild” have drawn the following lessons learned from this project:

- That training should go beyond providing information and awareness raising to building skills and competencies
- That retrofitting for energy efficiency will require a long term, co-ordinated and stable regulatory framework to provide cost effective solutions
- That property owners require independent and trusted guidance from energy advisors and building professionals

One of the success stories arising out of the work of “Trainrebuild” has been that achieved by “French National Property Owners Association Partnership on Retrofitting”.

7.1.1 “French National Property Owners Association Partnership on Retrofitting”

The partners in this project were the UNPI (Union Nationale de la Propriete Immobiliere) TOTAL and Econormes Habitat – a company which specialises in energy performance certification and consulting on energy efficiency renovation. The aim of the project was to increase the take-up rate of energy efficiency refurbishment amongst residential property owners, through subsidies and providing easier access to funding. Owners were able to choose their contractor to undertake the work and the subsidy was then paid directly to the owner upon completion of the work. Eco-loans at zero interest rate and tax incentives were also available to support sustainable development work undertaken by individual owners.

Eligible energy efficiency renovation work had to fulfil several conditions. Improvements had to achieve specified levels of energy efficiency; the work had to be undertaken by a qualified professional and only accredited products could be specified, which met minimum performance standards. The administrative process required that all work had to be properly costed and verified upon completion. www.unpi.org/
7.1.2 The KIQ (Kooperation im Quartier) Project in Germany

A second successful “Trainrebuild” project involved the German property owners association Haus and Grund Deutschland, as part of a research programme run by the Federal Ministry of Transport, Building and Urban Development, together with the Federal Institute of Building, Urban Affairs and Spatial Development. The project runs from 2011 to autumn 2014. The KIQ project recognises the growing importance of private initiatives – where most residential buildings in Germany are privately owned – in creating sustainable housing and inner city neighbourhoods.

The project objectives were to encourage the renovation of the building stock – including energy efficiency renovation- by mobilising private owners and generating closer co-operation between local authorities and property owners’ associations.

Through eleven pilot projects, different forms of co-operation between private owners and municipalities are being tested, by providing exemplary affordable and suitable solutions to sustainable renovation. One aim of the project is to increase the value of real estate in local areas.

The KIQ project is innovative in the sense that it involves representatives of property owners as direct facilitators between local authorities and property owners in promoting energy efficiency improvements at a local level. Best practice examples and materials developed to promote energy efficiency in privately owned properties through the “Trainrebuild” initiatives, were applied through the KIQ pilot projects. www.hausundgrund.de/

7.1.3 EN-zyme Association Italy

A third successful spin off from “Trainrebuild” is the EN-zyme Association established in Italy in October 2012. In partnership with Citta Studi Biella, the Association aimed to promote training and new methodologies and technologies to improve energy efficiency and the wider adoption of renewable energy in buildings.

The Association uses the service package produced by the “Trainrebuild” project to promote a cultural change amongst individual property owners
in retrofitting buildings. This service package was adapted for training in Italy to include: web based technical assistance and a toolkit for retrofit evaluation offered to property owner association members.

En-zyrne aims to fill an identified gap between high level, expensive energy efficiency improvements and the needs of the majority of owners, whose buildings barely meet minimum national legal requirements on energy efficiency.

The expected outcome is to implement energy efficiency improvements and raise comfort levels at acceptable costs, through interventions undertaken by technical experts as a way of reassuring property owners. www.cittastudi.org

7.2 THE BUREAU OF INTERNATIONAL RECYCLING - BELGIUM

The Bureau of International Recycling (www.bir.org) is the Belgium headquartered global recycling industry association, which represents companies and affiliated federation from 70 countries. BIR works to encourage best industrial practices in recycling in order to keep the environmental impact of economic development to a minimum.

The use of recycled material can help reduce energy consumption and reduce environmental damage by conserving raw materials and diverting material from landfill or incineration. Interestingly Chinese organisations and companies are keen to adopt recycling methods and technologies to reduce the environmental impact of urbanisation and to underpin a sustainable form of economic development. Reports, tools and campaign materials on the environmental benefits of recycling are available in a number of European languages. The tools available cover the implementation of: sound environmental management and quality management systems which are compliant with the requirements of the International Standards Organisation.

The Department Leefmilieu, Natuur en Energie (Department of Environment, Nature and Energy) of the Flemish Government in Belgium provides a website www.ine.be/campagnes/bouw-gezond for homeowners and their advisors on how to maintain healthy homes. Information is provided on choosing
building materials and products, insulation and ventilation to minimize the harmful effects of substances on occupants. The available guidance covers advice on the choice of furniture, paints, lacquers, varnishes, floor coverings, and glue. Many construction materials contain volatile organic compounds and advice is provided on ventilation and protection against their harmful effects.

Further information is provided on the website on the implications of insulating homes to meet building permits whilst providing ventilation to maintain healthy indoor air. In older homes fresh air enters through cracks and other imperfections in the building envelope, but in highly insulated new construction there is now a requirement for a ventilation system, with natural or mechanical supply and discharge.

7.3 HERITAGE COTTAGE - WALES

Buildings of traditional construction are frequently misunderstood by construction experts when addressing energy efficiency and sustainability and consequently they are often treated in the same way as modern buildings. A research project underway in Wales by “Cadw” seeks to better understand building performance through detailed analysis of building design and construction. The research is being conducted in a typical old terraced house and aims to examine real thermal and moisture performance, how these relate to the environment of the building and to occupancy; the real costs and benefits of energy efficiency measures and focusses on establishing realistic solutions for wider application. The researchers emphasise that energy efficiency is not simply about installing energy improvement measures, it requires professional training, detailed analysis, understanding and craft skills for implementation work. Cadw is the Welsh Government’s historic environment service whose remit is to provide an accessible and well-protected historic environment for Wales, www.cadw.wales.gov.uk.

Heritage Cottage is a small nineteenth century, terraced house which is representative of so many traditional buildings in Wales and elsewhere. In Wales one in three buildings are traditionally built in this form. The Cottage will be used as a learning resource to highlight how a traditional building can be energy efficient and sustainable with a minimum amount of work, whilst retaining its character.
A detailed analysis of the building has been conducted focusing on its physical condition and energy performance, involving detailed analysis and different testing methods. Testing before and after repair and retrofit work helped to identify incremental energy efficiency improvements that were created, firstly through restoring the building to a state of good repair and then those attributed to retrofit work.

### 7.3.1 Building repair creating energy efficiency

Maintenance and repair that keeps a building dry and free from draughts can improve energy efficiency if it is done properly. Damp walls can increase heat loss by up to a third. The repair work at Heritage Cottage will include removing existing inappropriately applied cement mortar pointing, which can develop cracks and then allows rainwater to ingress and stops it from escaping. Walls will be repointed in lime mortar which allows moisture to escape and, therefore, lowers moisture levels.

Double hung timber sash windows, once they are repaired and draught proofed, can reduce air leakage by 86% thus improving their energy efficiency. Other repair work that leads to energy efficiency includes lime rendering the rubble...
stone rear elevation, repair work to the rainwater gutters and pipes, repairs to the chimney stack and roof covering.

7.3.2 Retrofitting for energy efficiency and sustainability

There are a range of retrofit measures that can potentially be implemented at Heritage Cottage. This includes installing secondary glazing, which could increase the energy efficiency of windows by 63%. Insulated timber shutters with secondary glazing can make a combined energy efficiency improvement of 77%.

Other improvement measures include reinstating the lobby at the front entrance and constructing a lobby to the rear where there was previously an out building. Loft insulation, low energy light-emitting diode (LED lighting, low energy heating, renewable energy, good heating controls, smart metering along with water conservation measures are being considered. However, it is the conclusions of the research and analysis on building performance that will determine the most appropriate retrofit measures to be adopted.

7.3.3 Analysis of the building

A very detailed survey has been undertaken which includes in-depth analysis for damp and timber rot. Other tests have also begun on measuring the in situ “U value” which is a measure of thermal resistance - see the charts below. When the u values are compared with published data - which is what is almost always relied upon - the U values of the external walls of Heritage Cottage are up to 30% better than they were thought to be. This highlights the potential discrepancy in U value calculations in all properties like Heritage Cottage and this is supported by other studies that draw similar conclusions.
Fig 7.3. Thermal values of external walls

Walls – what is the thermal value?

<table>
<thead>
<tr>
<th>Build Desk U-values (W/m²K)</th>
<th>In-situ U-values (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear (Build Desk U-values)</td>
<td>Underestimates In-situ U-value performance in 79% of cases.</td>
</tr>
<tr>
<td>Overestimates In-situ U-value performance.</td>
<td></td>
</tr>
</tbody>
</table>

Overestimates In-situ U-value performance.
Fig 7.4. Thermal efficiency and dampness in external walls

Other testing and analysis includes the undertaking of thermal co-heating tests which will measure how efficient the building is in using energy; infrared thermography to detect where energy is leaking out of the building and air leakage tests to identify the location of draughts. The research methodology includes monitoring how environmental conditions are affected by the weather and use of the building and how this all impacts on the thermal performance if the building envelope and moisture movement, as this also relates to the physical condition of the building fabric.

Since the 1960s box sash windows were thought to be old-fashioned and not suitable for modern-day living. This type of window, however, offers many advantages. Windows can be closed to provide a narrow gap, which allows good ventilation but stops rainwater entering and in hot weather sash windows can be opened very widely.
The perceived downside outweighed these advantages. By the 1960s occupants did not want rattling, draughty box sash windows, which required regular maintenance. Homeowners demanded “modern” close-fitting casement type windows, with the result that sash windows have been replaced on a grand scale since that time. Unfortunately the real benefits of sash windows – economic, energy efficiency and sustainability – were not properly understood.

Instinctively, it has widely accepted that replacement PVCu double-glazed windows are more energy efficient and should pay for themselves with reduced energy bills over a number of years. Researched commissioned by the Royal Institution of Chartered Surveyors suggests that this payback period could take more than 100 years!

Researchers at Glasgow Caledonian University have demonstrated that repairing a window to ensure that it functions properly, together with draught-proofing can reduce air leakage by more than 80%. Installing secondary glazing can improve the thermal performance by a further 63%. This is comparable to the performance level attained by many modern double-glazed window systems. Alternatively, the use of internal timber shutters used with secondary glazing can lead to a massive 75% improvement.

The Heritage Cottage project will encourage the retention of best practice in craft work to restore buildings to their original appearance and recapture the integrity of their design. Providing the right type and quality of timber is used, researcher have demonstrated that new sash windows are likely to last much longer than their counterparts constructed in modern man-made materials.

### 7.3.4 Conclusion

85% of buildings that will exist in 2050 are with us today. The output from this and similar projects assist construction experts and building surveyors in understanding the relationships between basic repair, maintenance, retrofit options and energy efficiency. Interestingly the research at Heritage Cottage includes using building information modelling as a tool for integrating and managing information and for providing online training.
7.4 PLANNED MAINTENANCE SURVEY ON A LARGE COLLEGE SITE - ENGLAND

Fig 7.5 Campus comprising a mix of property

In April 2013 a rural college of further education in England commissioned an asset management survey to inform the preparation of a new master plan for the site, assess backlog maintenance and provide a current and comprehensive information base for planned building maintenance and a facility management. The main campus comprises 21 hectares and 180 buildings, which range in age, size, form of construction, suitability and physical condition.

The survey specification – see table below - required a measured survey and preparation of CAD plans; a building condition survey to produce a detailed maintenance profile for five years; a reference survey extracting net and gross
internal areas room and floor areas from the CAD plans and fourthly a cost valuation for insurance reinstatement purposes.

**Table 7.1 Survey output format**

<table>
<thead>
<tr>
<th>Specification objectives</th>
<th>Output format</th>
<th>Features &amp; methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured survey</td>
<td>AutoCAD dwg files</td>
<td>Room and floor number convention</td>
</tr>
<tr>
<td>Building condition survey</td>
<td>Excel file</td>
<td>Building element condition/ priority coding convention; approximately quantities and costing method</td>
</tr>
<tr>
<td>Reference survey</td>
<td>Excel file</td>
<td>RICS code of measuring practice. Desktop exercise</td>
</tr>
<tr>
<td>Reinstatement valuation</td>
<td>Template per building</td>
<td>RICS code of assessment. Desktop exercise</td>
</tr>
</tbody>
</table>

The surveys included visual inspections of all building services, fabric and finishes. The building survey incorporated an assessment of the physical condition, together with an appraisal of functional suitability of internal spaces and whether repair or replacement works constituted an improvement. The future cost of individual items of work of the plan period was calculated using a specified source of building cost indices.
### Table 7.2. Extract from building condition survey output

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</thead>
<tbody>
<tr>
<td>A6 A1</td>
<td>Front right hand side</td>
<td>Brickwork repair</td>
<td>D</td>
<td>F</td>
<td>2m²</td>
<td>2 M</td>
<td>N</td>
<td>£310</td>
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<td>£317</td>
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<tr>
<td>A6 A2</td>
<td>Front south west</td>
<td>Brickwork repoint. Scaffold allowed across frontage for all repairs</td>
<td>D</td>
<td>F</td>
<td>32m²</td>
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<tr>
<td>A6 A3</td>
<td>Front centre</td>
<td>Spalling brickwork</td>
<td>D</td>
<td>F</td>
<td>3m²</td>
<td>2 M</td>
<td>N</td>
<td>£650</td>
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<td>A6 A4</td>
<td>Front</td>
<td>Repair brickwork window cills</td>
<td>D</td>
<td>F</td>
<td></td>
<td>2 M</td>
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<tr>
<td>A6 A5</td>
<td>Front right hand side flank wall</td>
<td>Repoint and repair brickwork</td>
<td>D</td>
<td>F</td>
<td>2m²</td>
<td>2 M</td>
<td>N</td>
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<td>A6 A6</td>
<td>Front</td>
<td>Replace lead cappings</td>
<td>D</td>
<td>F</td>
<td>60m²</td>
<td>2 M</td>
<td>N</td>
<td>£3,000</td>
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<td>A14 A8</td>
<td>Front</td>
<td>Repaint cast iron and steel doors</td>
<td>D</td>
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<td></td>
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<td>Front</td>
<td>Refix Lightning Conductor</td>
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<td>F</td>
<td>15m</td>
<td>2 M</td>
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<td>A1 A9</td>
<td>Front</td>
<td>Refix slipped tiles &amp; check others</td>
<td>D</td>
<td>F</td>
<td></td>
<td></td>
<td>1 M</td>
<td>N</td>
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<tr>
<td>A1 A10</td>
<td>Front</td>
<td>Repoint ridge tiles</td>
<td>D</td>
<td>F</td>
<td>17m</td>
<td>2 M</td>
<td>N</td>
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<td>A15 A1</td>
<td>Building Perimeter</td>
<td>Clear Gullies</td>
<td>D</td>
<td>F</td>
<td></td>
<td>1 Item</td>
<td>1 M</td>
<td>N</td>
<td>£75</td>
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<tr>
<td>A15 A12</td>
<td>Rear Left Hand Side</td>
<td>Replace damaged IC cover</td>
<td>D</td>
<td>F</td>
<td></td>
<td>1 Item</td>
<td>1 M</td>
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<td>Front roof mansard</td>
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<td>A7 A14</td>
<td>Front Ease, repair and paint steel casements in timber sub-frame</td>
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<td>D</td>
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<td>6 No</td>
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<td>Front Ease, repair timber door</td>
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<td>D</td>
<td>F</td>
<td>2 No</td>
<td>2 M</td>
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<td>A6 A16</td>
<td>South Above Entrance</td>
<td>Brickwork repairs</td>
<td>D</td>
<td>F</td>
<td>1m²</td>
<td>2 M</td>
<td>N</td>
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<td>A14 A17</td>
<td>South</td>
<td>Repair and re-paint cast iron rainwater pipe and SVP</td>
<td>D</td>
<td>F</td>
<td>4 No</td>
<td>2 M</td>
<td>N</td>
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<td>Right Hand Side Flank</td>
<td>Repoint right hand side</td>
<td>D</td>
<td>F</td>
<td>3m²</td>
<td>2 M</td>
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<td>Right Hand Side Flank</td>
<td>Windows, Scaffold included for other repairs</td>
<td>D</td>
<td>F</td>
<td>8 No</td>
<td>2 M</td>
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<td>Rear Single Storey Extension</td>
<td>Repair and repoint</td>
<td>D</td>
<td>F</td>
<td>20m²</td>
<td>2 M</td>
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<td>A1 A21</td>
<td>Rear Single Storey Extension</td>
<td>Replace felt</td>
<td>C</td>
<td>F</td>
<td>20m²</td>
<td>3 M</td>
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<td>A14 A22</td>
<td>Rear Left Hand Side</td>
<td>Windows off scaffold tower</td>
<td>D</td>
<td>F</td>
<td>4 No</td>
<td>2 M</td>
<td>N</td>
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The combined survey output provided a comprehensive information base for college principals to assist them in the strategic and operational planning and management of the property estate. Up to-date as built plans have numerous applications in space management, risk assessments, refurbishment feasibility studies and project procurement. The five year maintenance plan identifies, prioritises and costs maintenance need and supports the business case in seeking funding; the reference survey schedules are used in assessing space needs and re-charging for use, whilst the reinstatement valuation is used to negotiate building insurance premiums.

The surveys were undertaken in accordance with good practice methodologies and professional codes of guidance. The challenges in carrying out the project, which were identified in the project risk management evaluation included:

- Working in occupied buildings
- Security measures whilst working in student accommodation
- Arranging safe and prompt access to flat roofs, roof voids and plant rooms
- Programming to ensure that the critical path of plan preparation – asset survey – reference survey – cost reinstatement was followed
- Maintaining consistency of approach across the team of construction experts and services engineers in the use of coding systems for building elements, location description, condition/priority, and for quantifying and cost estimating
- Ensuring the survey of each building was complete – particularly where properties have mixed use, adjoin and where boundaries are unclear, and also where the intensive use of the building required multiple visits
- Defining performance and condition standards for individual building in an estate comprising proprieties of mixed age, functional suitability, form of construction, size, complexity and type of use
- Neither hard copy or digital plans existed for the majority of buildings

The survey team took two months to complete the surveys on site during term time. With the appropriate administrative support the survey output was delivered in month three. Mobile devices tablets were used for data capture during the site survey. For the measured survey of larger buildings the building footprints were plotted using a total station (an electronic theodolite integrated with an electronic distance metre).
Carrying out the building condition survey required the identification of defects affecting the performance of plant, installations and the building fabric and an understanding of cause and appropriate maintenance and remedial actions. Managing maintenance is fundamentally concerned with preventing failures that can lead to undesirable outcomes before they occur.

Undertaking the survey required a thorough knowledge of physical and operational condition, functional suitability and performance, safety and statutory requirements, energy and environmental performance and life cycle costing techniques.

The development of an excellent property information system is central to good asset management, as the information is essential in optimising the planning of future maintenance, whilst matching available resources against competing demands. The output of this survey when combined with property valuation and cost in use data, provides a sound platform for strategic investment and operational management decision making, to meet the continual changes required in a learning and teaching environment.
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Affiliations of the Monograph Author:

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