

Design for maintenance from the viewpoint of sustainable hospital buildings

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Introduction

The aim of this paper is to provide a commentary on poor design for maintenance of services in hospital buildings. The author discusses and elaborates on the missing links between vital design, installation maintenance and sustainability.

In the construction debate the relationship between the quality of building design and the requisite green issues are often missing. The author also gives his comments on the best management of design and maintenance so that pragmatic ways can be used to improve building care and sustainability. This paper summarises the author's vision of sustainable construction as a result of enlightened building services engineering that embraces fully integrated design, construction and operation in a seamless process. Most significantly, there must be a focus on clients' interests, and all construction professionals should treat maintenance aspects as a significant part of any design work.

Maintenance and the built environment

What is maintenance? The Oxford Dictionary defines 'maintain' as cause to continue. Maintenance, therefore, is ensuring that physical assets continue to fulfil their intended functions. If a green building is specified, it is essential that all building elements and the dynamic building services element must meet the requirements of the building (e.g. useful, flexible/adaptable for continuing changes, cost effective and sustainable) and capable of being maintained to continue in the required conditions.

Good design is in itself maintenance, and non-maintenance is a factor/product of good design.

Putting maintenance at the centre of the continuing post-Egan reform process is long overdue. A common design problem is lack of design for maintenance for building and building services. Many buildings are not completely maintainable. They cannot be adequately maintained because the quality of design inhibits maintenance. Many professionals have not yet concentrated on good planning of maintainability for all building elements. Though considered important by many, the aspect of maintenance is seldom fully taken into account during the building process. The outcome is low quality of building and services with poor maintainability. This often leads to a poor building and ultimately dissatisfied clients.

Directly and indirectly, the quality of such buildings can have a significant impact on building sustainability. Case studies indicate that design strategies can have a significant effect on operation and maintenance, user satisfaction, client business, profitability and the sustainability of building and services. It

is, therefore, necessary to critically appraise building services design together with the commonly neglected maintenance issue during the conceptual stage of a green building design to optimise the whole life aspects of building and its building services installations.

In recent years, much information has been put forth about the impact of the built environment on the natural environment - the concept of sustainability or green building issues and better design for our buildings. A vast amount of useful information is available for designing and constructing greener or better buildings. Nonetheless, studies on maintenance of building and its building services in conjunction with sustainable building care (i.e. use of building and the continuing maintenance) appear to be scarce. Apparently, the industry tends to focus too much on glamorous new construction, still leaving the maintenance aspect as a Cinderella of the design and construction process. Design for maintainability is rarely discussed and often neglected by many in the industry.

Hospital engineering services

Hospital engineering services are one of the faster developing forms of technology within hospital building. The cost of services can fall between 10% and 50% of the total construction cost (excluding land cost). It is not just the initial capital cost that a designer has to take into account when choosing the mechanical and electrical services system. The operational costs, maintenance costs, life expectancy and the use of the building have to be considered.

Building sustainably

To begin with, we must have a mutual understanding of sustainability. There may never be a consensus view on its exact meaning. However, one way of looking at sustainability is the ways in which built assets are procured and erected, used and operated, maintained and repaired, modernised and rehabilitated and reused or demolished and recycled. Sustainability constitutes the complete life of building construction activities. Given this long definition, it is vital that sustainable issues are given due consideration as early as possible during the procurement process. As seen from this definition, sustainability is not a building fashion, but a concept of good building design incorporating the best environmental management for the building, its people, the indoor and outdoor environment.

Sustainable building is sustainable development. At its basis, it is the three tiers of environmental, social and economic contexts. Better designed buildings can improve the quality

of life. It has been demonstrated that sensible sustainable development reduces operating cost while providing better buildings that enjoy greater occupant satisfaction and that the designers (i.e. specialists of design and operation) had a crucial role to play in developing appropriate sustainability.

Some designers may address energy consumption and the environment without giving due consideration to issues such as reducing design margins, minimising redundancy, simplification of complex designs or improving standardisation. These can all have a far greater long term impact on sustainability over the average life of a building. Hence, the building services engineer has considerable influence on the environmental performance of buildings through involvement in design and operation.

Sustainable building care

'Green' has been recognised as a social and political term but 'green' also means that a function should be both human and environmentally friendly. There is a growing awareness of the connection between good design and maintenance and the green issues.

Building care is a part of the sustainability issue. Building care is customer focused, and encompasses the management and maintenance of premises and its building services. The quality of maintenance or building care will have a significant impact on the delivery of appropriate sustainability performance of a building. Obviously, to attain the highest building care and the best sustainability, the most effective way is to design maintenance in conjunction with the development of a green building during the outset of a project.

Considerable emphasis has been placed on close coordination between members of a project team, all seeking mutually acceptable solutions to the green design challenge and maintenance issue. It will take practical and innovative as well as synergistic designs that cut across design disciplines to achieve true success and high quality. This will result in a more sustainable building that achieves high performance, over the full life-cycle, in the following areas:

- Lean design with appropriate technologies
- Design attuned to use of building
- Higher sustainability in terms of energy air/water pollution and use of resources
- Low maintenance but higher reliability, durability, adaptability, availability and longer useful working life
- Low obsolescence and high reusability

The maximum value of sustainable building care is obtained by considering the areas stated above at all stages of a project. Sustainability needs to be considered in design and construction and in use. Spending time in researching and considering different solutions at the design stage has the greatest impact on achieving a sustainable building. Time well spent in preparation and design will enhance the effectiveness and efficiency of a sustainable project. Designing better buildings means more efficient construction techniques along with better building services. This will lead to improved maintenance and operation of the existing building stock which can bring economic, social and environmental benefits.

A sustainable building and sustainable maintenance are

possible; one presupposes and requires the other. In theory, while zero maintenance may be striven for, it is ultimately unachievable in practice. Some maintenance will be necessary and, indeed, desirable, if one wants to ensure the highest performance and reliability of the building systems.

In good design, a minimum maintenance model in which the design of maintenance is based on good engineering principles could include:

- simple design,
- functional analysis,
- reliability centred maintenance,
- fault analysis and risk identification,
- optimising operation and maintenance
- a combination of all planned maintenance techniques and systems

If a building is to be sustainable, it is essential the services are capable of being maintained to continue in the green performance conditions. Issues such as selection of materials, processes, systems, effective and efficient plant operation, maintainability, standardisation, durability, health and safety – all are (in addition to energy efficiency environment issues, waste reduction etc) significant components of the sustainability debate. They are whole life issues that need to be in the right context at the design stage.



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Building services design incorporating maintenance

The intensification of building services installations and the increased use of modern technology has resulted in modern hospitals being one of the most complex of present day building types. It is important, therefore, that the subject of maintenance needs to be addressed much sooner in the design stage to ensure that the design of proper maintenance is fully integrated into a building design.

The implications of building services installations on hospital design are many and varied with their inter-relationships complex. These implications not only influence the planning process of design but in many instances actually dictate the planning (not just two-dimensional, but three-dimensional considerations for the accommodation of services, etc.). The implications of building services permeates throughout every aspect of hospital design so that the resulting whole becomes an integrated matrix of building fabric and building services with elements interdependent on each other for function, support, protection, operation and maintenance.

The effect of the building services design not only encompasses the consideration of simply containing the various services, but also the parallel effects of the construction method, accommodation of services and the future maintenance needs. All in all, hospital design and building services are one which cannot be separated or considered in individual categories, and without team effort, it is impossible to produce a useful, flexible and sustainable hospital.

The hospital services designer has a range of equipment from which to select, can dictate how it will be installed and how the components will be brought together to form the various systems to produce a functioning building. A multi-disciplined design team has professional responsibility to design out maintenance and/or make suitable provisions for maintenance. The building services designer should have a higher professional responsibility to influence the remainder of the team in the decision making process in relation to the neglected maintenance of services after their physical installation. Clearly, the design process can have the single largest impact on sustainable development. Cutting back on

the time and resources required for a good design is a recipe for delivering poor quality outcomes.

Designing sustainability in a project life

In the construction industry, many design engineers design the building services systems, supervise the installations and handover to their clients, wash their hands and leave the operation and maintenance (O&M) staff to suffer the rest of the 50 years. Some building services design engineers are too keen to apply available technology without due regard to the required provisions for maintenance and O&M staff have little chance to participate in the design stage. On the other hand, the know-how in industrial plant O&M is not adequately applied in buildings. The following sections highlight some important issues for consideration when contemplating the design of a sustainable building.

Control of maintenance

The primary consideration of a building design is the production of a functional facility. Since the functional requirement drives the design, there is a tendency to concentrate on this aspect of the design at the expense of other considerations, especially maintenance as the last thing on the designer's mind. However, the conceptual phase of a design is the single point in time at which there is control over the future maintenance and operating cost of the facility. The ability to control or modify maintenance diminishes from the earliest step in the design process as shown in table below.

Important consideration for good maintenance

Problems of maintenance will result in high cost penalties including loss of service, high cost of repairs and, sometimes, unnecessary building damage. It is important, therefore, to consider the maintenance operational policy at an early stage in the design process to ensure that a maintainable building is possible.

Factors determining the approaches are:

- Capital costs
- Complexity of building design and intensity of engineering services in the building

STAGE

CONTROL

Concept	Total control – building and services can be tailored to any maintenance philosophy; designing out maintenance will eliminate most problems.
Design	Total control - flexibility remains to select systems which have low maintenance requirements.
Construction	Very limited control – design is fixed; difficult to change design but still possible at high cost; inspection will identify maintenance problems (not ALL).
Building in use (a life of 50 to 60 years)	No control – maintenance problems will develop and appear.
	Repair – very limited control, minor corrections to maintenance are possible.
	Replacement – still limited control, but can reduce on-going problems.
	Improvement/modification – control flexibility is a little better, but may give good control (NOT TOTAL unless the whole system can be changed).

- Use of simple technology, avoiding the use of special systems, labour and material
- Level of reliability, durability and availability
- Future flexibility of layout and flexibility for changing client needs
- Consequence of failure or disruption of services and cost of failure
- Frequency of maintenance operations in conjunction with maintainability
- Health and safety aspects
- The acceptance of new design ideas with greater integration of building and its building services
- Maintenance with adequate access
- Obsolescence and quality of system/equipment to facilitate good use of building
- Impact on the environment

We have to re-engineer our practice (e.g. value analysis, risk evaluation and analysis, functional analysis and the process of continuous improvement such as design and maintenance audits) and give better designs to improve the requisite sustainability. With the increasing complexity of modern services, it is more than ever essential that the engineering and architectural aspects of a project are developed simultaneously from their inception. Most importantly, the types of services installation to be used should be identified before the overall architectural design is finalised and the necessary plant spaces determined.

Focusing on good design

We have been using conventional design solutions for many years. Some work and some do not work satisfactorily. As a responsible designer, it is our duty to incorporate the best solution in order to satisfy the client's needs. To succeed, we need to emphasise prevention/elimination of maintenance problems.

Blind adherence to standard hospital design templates will no longer give good value for money to the client. Often there is a conflict of views of the members of the planning team, particularly in the relative importance of the clinical as opposed to the servicing. The answer must be better team work and the imposition of a strict discipline to all planning negotiations.

Designing better O&M

It is important for the design team to have a vision of the life cycle of the building, rather than considering it simply as a new building to hand over. All members in the project team should have:

- A clear policy that the design is to meet the O&M requirements during the life cycle of the building
- A position statement to elaborate the essential issues to meet such requirements

- An action plan to execute all possible procedures for meeting the O&M requirements.

During the design stage, there are, nevertheless, grey areas where it is not clear who has the responsibility. It is then advisable for the project manager to:

- Assign such responsibility to a designated person
- Have a schedule to constantly receive progress reports to avoid confusion and shirking of responsibility.

Designing maintenance out is the only answer

In the process of planning sustainable buildings, the project team should also consider the integration of services within the building envelope and structure through coordination meetings. The planning process should also include maintenance engineers in the project team. All designers should consider the following needs when planning a sustainable building.

- Ensuring that replacement or refurbishment is possible with adequate space and access and, without breaking the structure or building enclosure housing the services (this will save resources and also reduce waste)
- Checking whether any plant and equipment provided may become obsolescent before the end of design life.



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Also investigate the removal and replacement of this plant with the provision of suitable means of access for that work.

Barrier to designing maintenance

The ideal building is very rarely attained in part due to bureaucratic procedures, inflexible decision making, and an uncooperative culture within the industry. Hard cash normally accounts for a large part of the difference between what we would have liked to have had and what we in fact get.

The time is past when architects can refine a client brief without the help of engineers and other experts. The greener buildings become the more important it is for all project participants to start working together from day one.

Reconciliations of discussions

A strong case can be made for a return to fundamental simplicity in building design with scope for research in the integration of engineering services for better buildings. A fact finding survey of design/maintenance in highly serviced hospitals could prove to be a valuable exercise, confirming as it would, the need for closer collaboration between designer and maintenance engineer. Research is needed to give greener buildings with better services and maintainability all are properly balanced to obtain the desired performance with minimum expense.

Conclusion

Modern buildings are designed to meet more complicated needs than those of previous times. Increased space standards, higher environmental standards and new patterns of building use have affected hospital design and construction resulting in more complicated buildings. This means that

1. increasing reliance is being placed on building services to provide the environment and facilities needed
2. there is a growing need to ensure services are available when required and operated at an expected level of efficiency
3. the design influence on the maintenance of all building services and fabric is greater than ever before.

Maintenance of building services has been the Cinderella of the construction industry for too long. It is now emerging as area that requires more attention in the design of a building. Failure to maintain building services will affect building performance whereas improved maintenance will bring long-term benefit to our buildings. One of the key attributes of a well-designed, cost-effective, maintainable green building is that it is designed in an "integrated fashion" and maintenance is no longer treated in isolation.

To get the best green building, all designers have to adopt a rational approach to the management of services design, installation and maintenance. The design process is the first crucial element in producing a sustainable building. Once designed, the building must be constructed commissioned, and operated in a way that supports the sustainability concept. If it is not designed with the intent to make it sustainable the desired results will never be achieved.

In conclusion, a building will not be adequately maintained if the quality of design inhibits maintenance. Designers can greatly influence the future maintainability of our sustainable buildings. Hence, designers should improve whole life performance through either simple or innovative design solutions.

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