Design for Manageability: pointers from a decade of research on occupied buildings

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Since the mid-1980s, when the first studies of sick building syndrome were under way in the USA and UK, much has changed in the public perception of buildings . Health scares over legionnaires' disease and international efforts to reduce energy consumption in buildings, amongst other factors, have helped to encourage research effort on the human, social and environmental aspects of buildings, rather than just on technical, constructional and design topics. At first, many of the findings from this new work were treated sceptically, especially by the building professions, but now its perspectives are fundamentally affecting thinking about building management and design. In this paper, some of the pointers are explored, and implications examined, especially for strategic thinking about buildings and their occupants.

Introduction

Why do too many buildings deliver less than they promise? Barring major technical failure, a common answer is unmanageable complexity. Many buildings are prone to this, especially newer ones which try to integrate a greater number of activities at higher intensities and spatial densities and with better amenities than in the past.

In striving for improvements, designers often underestimate or ignore:

1. how systems - physical and human - can conflict with each other, thereby pulling performance levels down to lowest-common-denominators, and
2. how uncertainty and inefficiency in systems' operation and use can readily develop through lack of attention to detail for occupants' requirements.

Conflicts between systems and uncertainty in their use are symptoms of unmanageable complexity, a feature of modern buildings which arises from the tendency, first, to require too much of the building and then too much of its management. Often buildings are not designed with management and use in mind, and so can exhibit pathological characteristics - unnecessary over-use of fossil fuels, chronic illnesses of occupants like dry eyes, hot, dusty and noisy spaces, absenteeism, productivity losses, uncontrollable indoor environments and low user morale. Many of these are inter-related with the culture of the occupying organisation, and it is often difficult to attribute direct causes. Chronic features tend also to reinforce each other, so that once standards slip they become difficult and expensive to reverse.

These observations come from research on occupied buildings carried out in the United Kingdom over the past decade. In this paper, we offer some pointers which may be incorporated into strategic thinking about building design and use, especially some of the principles which should be introduced at the briefing stage of a project.

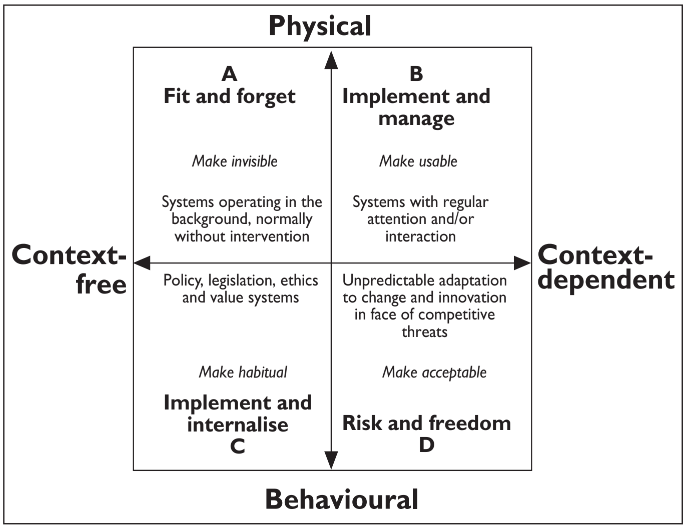
Most of the findings are based on projects with which Building Use Studies and William Bordass Associates have been directly involved: that is post-occupancy evaluations of new office buildings, studies of building services and energy consumption in offices, hotels, factories, retail, education and sports buildings, surveys of occupant ill-health and occupant control behaviour, and the effectiveness of active and passive design features.

General findings

Figure 1 (next page) illustrates some of our general findings. There are two attributes on the diagram.

1. Systems in buildings may be considered as either physical (top half) or behavioural (bottom half). Treated as integrated systems, including both physical and behavioural elements, most buildings are a mixture of tightly-coupled and loosely-coupled elements with interfaces between them. [Reference 1, chapters 1 and 5]. Physical systems (such as the building structure, walls and enclosed spaces, windows and ventilation systems tend to be *tightly coupled* (meaning that there is relatively little slack or give between them [Reference 2, page 90]). Behavioural systems are *loosely coupled* (meaning that certain parts express themselves according to their own logic or interests [Reference 2, page 92]) .

Figure 1 Strategic design and management considerations



2. Attributes may be context-free (left-hand side) or context-dependent (right-hand side). Context-free attributes are systems and principles that can be applied to buildings independently of their operation. These should include:
   - features of buildings which should properly be relied upon to operate in the background, and be normally not noticed in everyday use;
   - most technical systems;
   - legislation governing building design and use.

   Context-dependent attributes need to be tailored to suit the requirements of the occupants, and need regular attention or action.

In addition:

- the top left of the diagram represents characteristics which are predominantly *spatial*, and normally created by designers who are usually outside the occupier's cultural system; and,
- the right-hand side is the province of occupiers, users and managers who are usually much more pre-occupied with *time dependent* systems.

The four quadrants

These two dimensions divide Figure 1 into four quadrants, which we have named:

A *Physical and context-free*
Something which can be taken care of physically and does not alter with operational context can be seen as "*fit and forget*": the location of most buildings certainly is; so to a great extent are passive features such as structural stability, fire compartmentation and insulation.

B *Physical and context-dependent*
The demands on these are forever changing and they cannot only respond passively: they include equipment which needs reconfiguring, replacing and servicing; furniture which needs to be moved about; and engineering systems which react to changing weather and occupancy. They need to be *implemented and managed*.

C *Behavioural and context-free*
These are things which one can take for granted in (or at least reasonably expect from) people. They are ingrained in social structures and habits, ethics and value systems, and supported by government policies and rules. For things to go smoothly, however, what one wants should be *implemented and internalised*, and it is usually much easier to go with, than against, the grain.

D *Behavioural and context-dependent*
The unexpected happens. Something goes wrong. All is going well until a telephone call changes everything! This is an area of *risk*, but *freedom* too.

Avoiding unnecessary demands

In general, the fewer demands a building makes on its occupants and its management, the more likely it is to work as intended. However, no building is infinitely durable and increasingly investors and occupiers want them to be "flexible" (more of this later). Nevertheless, we can identify important aspirations in all four quadrants of Figure 1.

A (Top left) *Make invisible*
Ideally, things that one can fit and forget and do their job invisibly, without intruding on the occupancy and use of the building.

B (Top right) *Make usable*
Things that need more changing around and looking after should be usable, and ideally by those most directly connected with them: it is better if you can move your own table and adjust

your own thermostat and light. It is better if you can get at the item needing maintenance rather than having to disconnect other things and lift them out of the way.

C (Bottom left) *Make habitual*
Designers may expect occupants to behave in unfamiliar ways. Occasionally this may be necessary: but if so a strategy needs to be carefully worked out, discussed and agreed with, and implemented by management. However, if what you want people to do fits in with the way they do things, it makes life much easier. If it is intuitively obvious, better still.

D (Bottom right) *Make acceptable*
Most hazards can be reduced to acceptable levels by a combination of physical, behavioural and managerial measures in the other three quadrants, plus risk management procedures. Few can be eliminated, at least at sensible cost (spending too much on reducing one kind of risk can easily divert funds from better and more cost-effective measures) and without unreasonable restrictions on freedom. Risks can also have a nasty habit of being shunted around: people in safer cars kill more pedestrians and cyclists! [Reference 3]

Unintended consequences

Many problems with buildings seem to occur because people either put things in the wrong quadrant, or fail to appreciate that they belong in several quadrants. For example, to the occupant, an open-plan office with air-conditioning behind the ceiling (or under the floor) may appear to offer the ultimate in flexibility. However:

- The system will always have some intrinsic limitations, which always seem to surface sooner rather than later.
- All the equipment behind the scenes will need looking after by somebody. Has it been made usable for them?
- The individual occupants and groups in the space may find it more difficult, say, to alter their furniture or their temperature than transfer these activities to management; and if response is not rapid, they may become highly critical.

The result is that rather than “fit and forget”. there is quite a big task in routinely looking after the facilities which were intended to provide the flexibility. If this is not well done, the consequences can be serious. “Fit and manage the consequences” (top left and right) might be a better phrase for it.

Perhaps it would be better to start off with something simpler, which makes less routine demands of management, even though it may require more substantial *ad hoc* interventions from time to time.

Designer and user perspectives

Although both designers and users usually try to create flexible buildings that respond well to changing requirements, they do so from different perspectives which are often incompatible. Designers tend to see buildings from the point of view of spatial constraints; users and occupiers from the perspective of time. The designers’ perspective tends to be biased in favour of the left-hand side of Figure 1; the users’, the right-hand side. Designers often stereotype or simplify user behaviour, or ignore it altogether [Reference 4, chapter 1]. Users often misunderstand or ignore the spatial and technological, cost and legislative constraints within which designers must operate.

As the authors have shown in a companion paper [Reference 5], designer and user perspectives can be complementary - especially when buildings are shallow in plan form and have simple heating and ventilation services - but tend to “fight” each other as soon as they get bigger and more complex. The rapid growth of the facilities management profession in the USA, Europe and Australasia in the 1980s and 1990s has partly come about to deal with conflicts and inefficiencies created by large, complex buildings in which design and user issues have not been clearly enough resolved.

In the authors’ experience:

- too much attention is given to visible spatial features of buildings at the expense of less obvious time-dependent features; and
- many unintended consequences arise from trying to assign building system attributes to the wrong part of the diagram, or not recognising the interactions between the various parts.

Many make the mistake that buildings can be designed and successfully run to standard procedures and performance specifications. This is rarely the case because of differences created by unique requirements of occupants and organisational cultures. Our experience is that building functions must be recognised for what they are and allocated appropriately, otherwise chronic, and occasionally catastrophic, problems will result.

Over-reliance on technology, and burgeoning legislation (designed in part to deal with technological overkill) tends to want to push functions into the left-hand side of Figure 1. The outcome is that buildings are becoming:

- harder to manage effectively; and
- surprisingly often less easy to change

At present, the vector of change seems to favour the top left of the diagram. More standards and codes to be met, less scope for discretion in design and management. We may be seeking too many context-free physical solutions to problems which belong (at least partly) in other quadrants, and often turn up there whether we like it or not. By expecting too much of the building and too little of management, a self-reinforcing prophesy is created if the very process in fact places additional demands of a different kind on management and makes it more difficult to make appropriate and useful compromises.

There is a danger that this trend could be self-perpetuating as designers, managers and legislators continue to seek technological solutions to what should more properly be considered as human management problems.

The implication is that more attention should be given to understanding outcomes of human behaviour in real contexts, especially in respect of:

- risky, abnormal or dangerous circumstances;
- decisions made when individual actions are further constrained by group behaviours, including how individuals and groups respond to sub-optimal internal environmental conditions;
- change, flexibility, adaptability and responsiveness of conditions to new situations;
- effects on behaviour and decision-making of changing work tasks;
- usability of control interfaces.

Each of these fall properly in the right-hand part of Figure 1, and all have been relatively ignored in the recent past.

Sought-after attributes

Figure 2 summarises attributes of buildings which studies have shown to be beneficial or sought after. These attributes could form the basis of a strategic brief for new or remodelled buildings. For the following sections, the supporting evidence will be found in the references.

Figure 2 The best buildings …

1. Respond rapidly and positively to triggers of change at all spatial levels (individual, workgroup and department).
2. Have enough management resources to deal with adverse or unpredictable consequences of physical or behavioural complexity.
3. Are comfortable and safe for the occupants most of the time, but use the properties of 1. if they become uncomfortable or unsafe.
4. Optimise relationships between physical and human (managerial) systems at all life-cycle stages (such as briefing, design, commissioning, use).
5. Are economical of time in operation for all user types (individuals at their workplaces, workgroups and visitors).
6. Keep resource inputs to a necessary minimum, as well as minimising undesirable effects which potentially infringe the rights of others.
7. Allow higher levels of functional integration to be retrofitted, if needed.
8. Do not introduce non-reversible failure pathways.

1. Rapid response

Speed of response is a topic rarely covered in the building literature, although widely in management science. [Reference 6]. The faster a building (meaning the whole building system, human as well as physical) can respond to requests for change from the occupants, the better people tend to like it and the more productive they say they are in it. [Reference 7] Speed of response applies in obvious ways such as the time taken by lifts to answer calls, or the time taking for a computer system to respond to a log-in request (four seconds is the tolerance threshold!) [Reference 8]. More emphasis is being placed on the speed with which furniture systems can be reconfigured, and possible cost savings by much more efficient relocation logistics.

Management procedures which react promptly to occupants' complaints also seem to be more appreciated, even if the source problem cannot be entirely solved. Where quick response is the norm, whether through physical control systems such as adjustable blinds or manually-adjustable thermostats, through building management support services, or a combination of both, occupant perceptions will usually be more positive and appreciative. [Reference 9]

One reason why occupants appear to prefer openable windows in many situations is that they have fast response and intuitively obvious control, even though they may not always deliver optimal or even reasonable conditions.

It is also important to have rapid response to failures within the technical systems. At present there are reasonably effective automatic systems to alert one to critical faults, for example a fire or a boiler lockout. Other faults (for example, lights failed) are quickly noticed by the occupants. Much less noticeable are chronic faults which affect efficiency but not service - or least not very noticeably. Examples include:

- wasteful operation of heating and air-conditioning systems, sometimes even running continuously;
- undetected malfunctions of energy-saving devices, such as heat recovery, free cooling and night ventilation systems.

Surveys often reveal that buildings designed to be energy efficient but which perform disappointingly suffer failures of this kind. For example, a review of case studies [Reference 10, pages 8 and 9] found that differences in energy use depended more on the detailed design, commissioning, control, operation and management than on the technical features adopted. Human management was at least as important as technology in securing good energy performance, particularly in air-conditioned buildings which had more potential for wastage.

2. Sufficient resources

Rapid response will usually be found in buildings where management has enough resources to deal with building-related problems both as and when they arise, and in advance. Good management will endeavour to set up self-reinforcing virtuous circles of causation which consistently "deliver" quality and responsiveness. However, most buildings are the victims of vicious circles which can become increasingly expensive to halt or reverse and spiral into accelerating decline. [Reference 11] For example, vandalism encourages further decline unless an environment is cared for: with immediate repainting or repairs, when the process can often be stalled. [Reference 12]

As often as not, the true costs of running buildings are under-estimated or ignored altogether by designers and senior management, forcing many buildings into vicious circles from move-in day. Building budgets are soft targets for cutbacks, partly because line managers do not have convincing data with which to defend themselves against attack from above. But much can be done in good briefing and design to reduce the management task by making things less complex and more self-managing.

As a rule of thumb, based on data from by the Building Services Research and Information Association (BSRIA) and data from Bernard Williams Associates [References 13 and 14], the annual spend on building services maintenance should be about the same as that for energy. This does not guarantee success, of course, but if the figures differ widely something may be wrong, especially if the energy spend is high and the maintenance spend low.

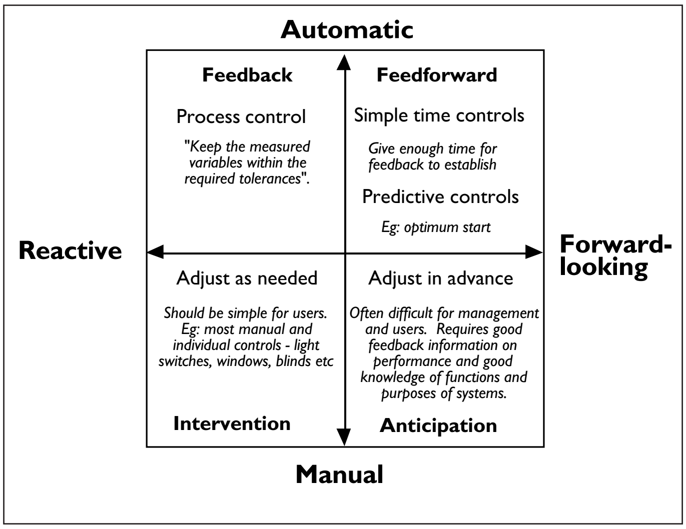
Building Use Studies' general experience is that maintenance of buildings leaves a great deal to be desired, either from knock-on effects of chronic long-term underfunding (as in many British schools for instance) or through bad maintenance habits and practices, including the appointment and supervision of outside contractors. Early work on sick building syndrome (SBS) in UK offices led many, including the authors, to think that SBS was primarily a design problem (with the main explanatory variables being physical features such as type of ventilation system or depth of space). As understanding grew, it became clearer that management, and maintenance, variables were more important than first thought [References 15, 16].

Designers and clients seeking flexibility, or energy efficiency, may unwittingly add to the management resource requirement and hence sow the seeds of failure. For example [Reference 10, page 9] noted that "complex energy systems may not be operated as the designers intended, and saved heating and cooling energy may turn up instead as parasitic losses from pumps, fans and unforeseen control problems". It goes on to say that "the greatest savings nationally are likely to come from simple applications of available technology in a manner which integrates architectural, engineering and user requirements, and provides control and management systems to suit".

3. Alleviating discomfort

One of the best kept secrets of work on thermal comfort in buildings is that alleviating discomfort is just as important for occupants' satisfaction as providing comfortable conditions in the first place [References 17, 18]. Occupant dissatisfaction with the indoor environment is directly related to occupants' perceived productivity [Reference 19] - the link between dissatisfied staff and lost productivity is much stronger than between satisfied staff and better productivity. On this basis, it may be better to give building occupants more capability to fine tune their environment than to rely too much on fully automated systems which in theory can deliver a better environment but may not be perceived as doing so. Designers often assume that comfort can be achieved solely by systems designed to "keep the measured variables within the required tolerances" and leave out the other features. The best buildings for com-

Figure 3 **Control strategies for building services**
Source: Reference 20



fort and energy efficiency require all four features shown in each of the quadrants of Figure 3. They need automatic control (top half of diagram) plus manual control (bottom half) and if possible should anticipate likely change (right half),and not just operate in response mode (left half). However, gratuitously adding more controls may introduce conflicts between different sub-systems and increase complexity beyond manageable bounds. For example, open-plan offices trade off personal controllability normally found in cellular spaces for greater inter-personal communication in the open areas (at least in theory, for many in surveys report it as an annoying distraction!). Productivity gains from better communication may not outweigh the productivity losses caused by more distracting, less controllable and usually hotter environments.

User control is important because people are often better than pre-programmed systems at dealing with unusual or unpredictable situations. The number of unusual situations is also likely to increase as space use is intensified. Like modern airline pilots who normally fly under autopilot but take control in difficult, unusual or emergency circumstances, building users need the capacity to make adjustments; their tolerance of conditions also increases as perceived control rises. For example, users seem to accept "poorer" conditions in naturally-ventilated than in air-conditioned buildings [Reference 21].

These considerations also apply in the arena of safety and health, and especially in the rapidly-growing subject of risk assessment. Figure 3, adapted from Reference 22, briefly illustrates some of the considerations. See also Reference 2.

Unfortunately, some engineering and energy-saving systems may create rather than alleviate discomfort. As a general rule it appears that:

- manual systems should operate perceptibly and give immediate response, if not by performing the intended function then at least by giving a click or lighting an indicator;
- automatic systems should operate imperceptibly: if not, whatever they do is sure to be wrong for some occupants.

Automatic control of lighting and blinds are common offenders here [Reference 23]: the blinds close either just as you are enjoying the sun or long after you have become fed up with it; the lights come on when you enter the room whether you think you need them or not; and other people's lights flashing annoy you. Automatically-controlled windows in new "green" buildings may create similar problems. Individual user over-rides of such systems are not costly luxuries, they are essential.

4. Optimise relationships between physical and human systems

Although buildings and their occupying organisations are recognisably complex systems, with many levels of interaction and feedback between sub-systems, many are designed, built and occupied as if they were independent systems with simple causality. It is commonplace to hear designers plead for their specialism (lighting, security, furniture and so on) to receive priority in the design process. This way they can avoid or minimise constraints deliberately or unwittingly imposed by others, and perhaps pass on some of their own for good measure!

True integration, with attention to detail and avoidance of unnecessary conflicts, comes through a well-developed briefing process which does not compromise the specialist designers' role. Later in the building's life, the brief should become the yardstick for post-occupancy surveys which objectively test whether it was met This information may then be fed into new building briefs, closing the quality improvement loop. The now extensive literature on "total quality" [Reference 24 is an example] offers many suggestions for building managers. For instance, techniques used in small-scale product development seem particularly appropriate to use at the larger building-system level [Reference 24].

For building and environmental services, it is important that the point of control is as close as possible to the appropriate point of need. Anything else will require access to management resources: which is at best wasteful, and usually means that an undesirable

Figure 4 Risk estimation considerations

Source: Adapted from Reference 22

Failure to consider the ways in which human errors can affect technological systems
Example: Obscure and difficult to operate Building Management Systems resulting in energy wastage and discomfort.
Over-confidence in current scientific knowledge
Example: Failure to take unproven scientific evidence seriously or develop precautionary strategies (eg global warming).
Failure to appreciate how technological systems function as a whole
Example: Overlooking importance of control interfaces in buildings, especially manual controls.
Slowness in detecting chronic, cumulative effects
Example: Building-related sickness
Failure to anticipate human response to safety measures
Example: Windsor Castle fire where emergency telephones were not seen by those wishing to raise the alarm.
Failure to anticipate common-mode failures, which simultaneously afflict systems which are designed to be independent.
Example: Failure of innocuous window components like friction hinges in naturally-ventilated offices simultaneously affecting noise, ventilation and heating performance.

state becomes the default state because it is the most convenient [Reference 20, and see also the next section on the economy of time].

5. Economy of time

Buildings operate over time as well as in space but far more attention has been given to performance in relation to spatial variables (like depth, height, shape and form) than over time. As a result, space and time systems are often poorly integrated and physical solutions proposed where operational approaches may have been better, and vice versa. In future, much more thought will be given to the way buildings work dynamically, especially to overcoming utilisation inefficiencies. Understanding time properly involves not just considering gluts and famines of occupancy, but also factors such as how habits, attitudes and behaviours influence the way systems work.

The best buildings keep to a necessary minimum time wasted by occupants moving about. This point is closely related to response times - the faster the need is met, the better. This applies not just to more obvious facilities such as the location of meeting rooms or toilets, but also activities such as photocopying, with major inefficiencies in queuing, machine downtime and travel time to the machine location.

Buildings too often default in performance to undesirable states which are extremely hard to alter. For example, many run with all their lights on all day because the first person who arrives in the morning in the half-light of dawn will switch all the lights on (at the gang switch near the door). Maybe they have no option, maybe the switching is incomprehensible, or maybe they just want to "cheer the place up". As successive people arrive, it becomes harder and harder to switch any off because of the difficulty of agreeing amongst everyone that this should happen. The building will thus tend to run "lights on" by default, whatever the daylight conditions outside. The combination of habit, poor control design, and the difficulty of making small-scale "trivial" decisions in groups leads to unnecessary inefficiency and sub-optimal working environments. Here, lack of integration between spatial factors and time factors (location of light switches, times of arrival) leads to buildings running "just-in-case" - that is, inefficiently and insensitively to true demand. Automatic daylight-linked controls are not the complete answer to this problem, as discussed in section 3. Human and automatic systems need to be sensitively combined [Reference 28]

Economy of time in fact unites all the features 1-5 in Figure 2. A simple rule is to make "the bad difficult and the good easy", which means comprehensible devices correctly located, easily operated, and configured to give rapid response and avoid unnecessary waste.

6. Sufficient resources

The best buildings match demand and supply and keep "just-in-case" running to a necessary minimum. Buildings which work best for human comfort and satisfaction also tend to be energy efficient [References 20, 21] probably because a good match of demand and supply is achieved through careful performance monitoring, attention to users' complaints and relatively rapid feedback loops and well-defined diagnostics. This is helped along by robust, well-designed, user-friendly systems. Effective cleaning and maintenance, and efficient energy management all involve active monitoring of systems' performance. The cleaning or the energy saving may not be most important part of these activities, but the monitoring and the culture which causes it all to happen. [Reference 25]

Buildings are undergoing a demand-side revolution of which the rapid growth of the facilities management professions is an important part. Emphasis on systematic building evaluation techniques is increasing, in an attempt to give potential occupiers a clearer understanding of strengths and weaknesses in advance of committing themselves to leases or purchase.

Through wider understanding of building performance - through investment, costs in use, technical features and human factors - clients are much more aware of the right questions to ask their design teams. Faced with an informed client, and far more focus on problem definition, designers must respond with better predictions of what their buildings will deliver. Architects and engineers now have less influence over briefs and the basic strategic agendas for buildings. This is not necessarily a bad thing, because more attention to needs and requirements provides designers with better problem definition in the building brief, to which they can then potentially give a better response.

7. Higher levels of integration

The best buildings allow more functions to co-exist, and are tolerant of higher levels of functionality. This is most apparent when buildings are altered to suit new requirements. Almost invariably, the altered space will be more densely occupied and accommodate a wider range of activities, for example, in higher education buildings which change uses from daytime to evening and from termtime to vacation and converting offices from cellular to open plan. The best buildings are able to accommodate higher densities as well as more functions operating simultaneously. However, there is a discernable trend both towards greater space intensification and increased obsolescence.

The desire for (or promise of) "flexibility" often leads to solutions which are reliant on energy-dependent technologies such as air-conditioning. However, in practice this flexibility may not be as great as was initially hoped, viz: all the materials - many often nearly new - which end up on the skip when an office is fitted out. An alternative route may sometimes be to provide a simpler, but potentially adaptable, building, but one which is easily altered as needs change. If properly thought-through, this can reduce both initial and in-use costs. "Mixed-mode" services concepts, which allow natural ventilation and mechanical systems to work together, are outlined in Reference 26.

8. Minimise failure pathways

Few buildings fail catastrophically in a technical sense. Many more fail economically, functionally, aesthetically or socially and exhibit chronic failures of one kind or another which often last for the lifetime of the building because there are no reasonable means of correcting the fault once it is there.

With the benefit of hindsight, some of these once latent faults seem blatantly obvious, but they can be hard to detect unless thorough briefing and design management disciplines are in place, plus appropriate testing of solutions. With the development of risk analysis techniques, which help prevent accidents in complex and dangerous systems like nuclear power plants [References 2, 27], one can now begin to target areas of most risk and put prevention strategies in place early in the design process. For example, in a naturally-ventilated building, the window is one of the most crucial building elements, so it is imperative that the window elements should operate reasonably effectively and in sympathy with associated systems, or failure in apparently "trivial" component can be excessively costly in the long term.

Conclusion: Design for manageability

Most of the pointers introduced here lead to the single conclusion: design for manageability. For manageability's sake:

- The fewer demands a building makes on management services, the better.
- Passive is better than active. Make sure that things which are designed to operate in the background properly do so.
- Things which needs changing or looking after should be usable, preferably by those who are most directly concerned with them. Responses should be rapid and understandable.
- Simple is better than complex, but when complexity is necessary package and isolate it wherever possible, and provide simple interfaces.
- Cater where possible for people's preference ranges rather than the average or norm. Try to foresee risky situations and how people may compensate.
- Identify potential failure paths and try to avoid them; if not, monitor appropriate indicators to help identify, and deal with, incipient problems.

- Beware of unsubstantiated promises of "flexibility" which may bring unforeseen management costs. Recognise that all situations are subject to constraints, which will show themselves sooner or later.
- Try to assess risk cost effectively, so that resources are realistically spent on avoiding the costliest and most risky events.
- Remember that designers are not users, although they often think they are!

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