5 Defining Conditions

This chapter identifies the fundamental importance of the creation of both physical and social conditions to the choice of construction. It establishes the need to specify internal requirements, define external conditions and then to identify the contribution of the activities of the occupants and the construction itself to the internal conditions. These conditions will be ever changing and therefore the whole system must be seen as dynamic, a series of flows seeking equilibrium. The chapter concludes by identifying how this process can be applied to the choice of internal elements, such as floors and partitions, and introduces the idea of microclimates within each element of the construction itself.

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Physical and social conditions

It could be argued that buildings are fundamentally concerned with providing physical construction to create the conditions for the well-being of those who use them. This statement would raise in most people's minds the modification of the natural environment: from the weather conditions outside the building to a less variable and more comfortable and safe environment inside. This is clearly a primary technical role for the construction, and therefore a clear understanding of the external prevailing conditions and a clear specification of the required internal conditions are of primary importance before any process of choice can begin.

Increasingly the external environment is being significantly modified by human activity by noise and air pollution that any understanding of the external environment must be more than just the natural weather conditions. It becomes necessary to understand the impact that producing and operating a building will have on the local, regional and even global environment.

The case for the need to understand the interaction of physical conditions is easily understood, but solutions chosen only against criteria of modification of the physical environment are not sufficient. Buildings are created in a social context in which they serve social functions that influence performance requirements. This simple idea is shown in Figure 5.1, which illustrates that the user's interests in modification concern both the physical and social worlds. If an activity can be carried out effectively within the limits of prevailing external conditions, and it is socially acceptable to do so, there will be no requirement for a building in any form.

It is important to remember that buildings have an impact on social conditions with both the internal and external spaces they create. While an understanding of social behaviour is beyond the scope of this text, it is well established that building may be part of social problems but can also be part of solutions. This is recognised in many aspects of urban design in areas such as crime and community safety.

The social context also determines the resources that become available for building. There is a need to understand the influence of the economic, political and cultural environments on the choice of construction set against its cost and its value in its wider social interactions. This has an influence in the specification of the required internal environments. The expectations of the user and the variations in

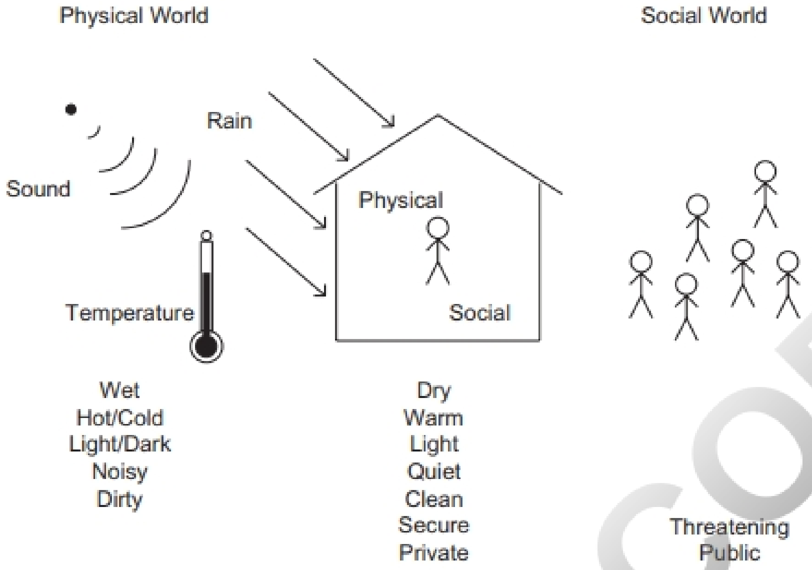

Figure 5.1 Physical and social environments.

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internal environment deemed acceptable are set against these wider social standards and the economic possibility determined by the amount of income clients are prepared to spend on their buildings.

Activity and construction-modifying environments

It is clear that construction modifies the external environment to create the desired internal conditions. However, the activities within the building will themselves contribute to the internal environmental conditions. Cooking generates moisture, heat and smells; machinery generates heat and noise; and cleaning activities generate waste. They will in turn, if detrimental to well-being, have to be controlled, which may increase the technical demands of the construction.

It also has to be appreciated that the construction chosen may itself modify the environment. This is particularly true of the services in building that often create heat, fumes and noise, but it can also be true of the passive construction. Poorly detailed insulation to resist the passage of heat to provide the thermal environment with lower energy inputs can induce condensation and create damp conditions. Finishing materials can give off toxic fumes in fire. Both are examples of the choice of construction affecting the achievement of the desired internal conditions.

The dynamics of the system

Although a stable internal environment may be the objective, it is clear that the external conditions and the levels of activity within the building will change in a variety of ways. This will produce constantly changing conditions. The whole system can be seen as a series of flows and transfers seeking equilibrium, as shown in Figure 5.2. This dynamic makes the process of control of the internal conditions a significant aspect in the process of choice.

Predicting the possibility of exceeding design limits in dynamic systems needs an understanding of both the variability of the conditions and the response of the construction providing the modifying effect. Indeed, a major consideration in choosing a solution may well be its ability to respond in sympathy with the expected magnitude and speed of changes in the environ-

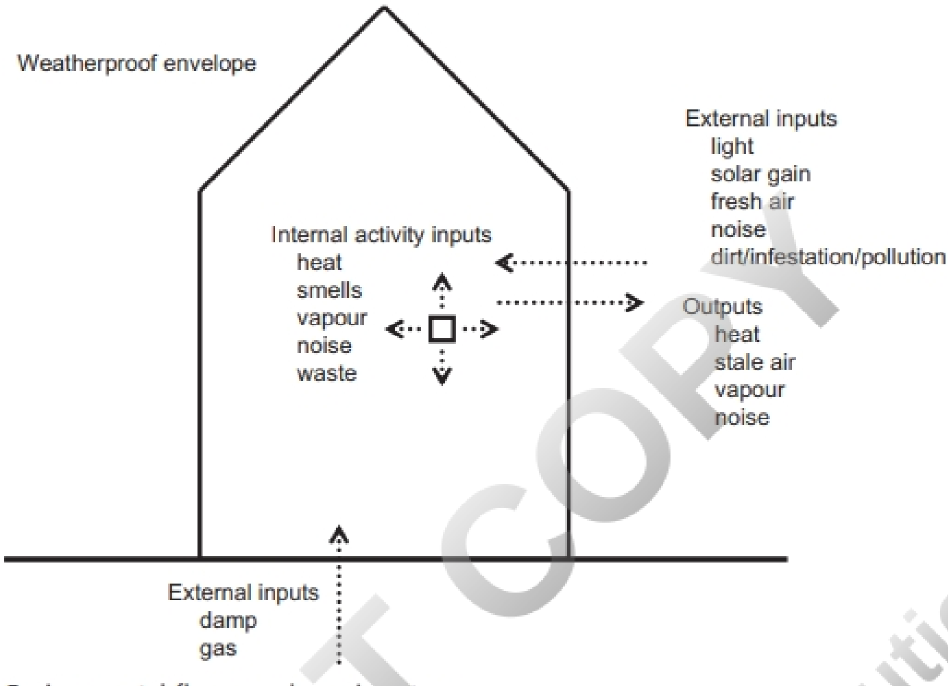

Figure 5.2 Environmental flows – a dynamic system.

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ment. This has been recognised, for example, in the advantages of high thermal mass for building in limiting the use of energy for cooling on hot days to limit the variations in the internal temperature between day and night.

To enter into an analysis of the behaviour of the construction it is necessary to define the following:

- Target internal conditions and acceptable limits within which the activity can operate
- Design limits in the external environment and their pattern and variations
- Inputs to the internal environment from the activity and construction including the response to changes in conditions

Target internal conditions

Defining the target or ideal internal conditions is a question of physiology and psychology in the case of people, engineering in the case of machines and spoilage processes in the case of stored material. Aspects of the environment important to the well-being of life, machines and materials have much in common. Temperature and dryness are often the most significant to the well-being of all three, although ideals and limits may be different. In cold stores the temperature is clearly dictated by the stored food. Any people or machines that also have to operate in the store have to be protected by other technologies (e.g. clothes in the case of people). In addition to temperature and dryness, consideration has to be given to aspects such as humidity, light, noise and air quality. The recent concerns over air quality, associated with hitherto unrecognised contaminants which occur in very low concentration, such as radon, illustrate how new aspects of environments can come into play as we strive for more demanding and less variable conditions.

People, machines and materials do not, however, need precise environmental conditions and can operate within limits. Indeed, in the case of people, constant, unvarying conditions can cause fatigue and some variations are desirable. Specification of internal environments is greatly influenced by social expectations and the resources clients are prepared to devote to the building. With low levels of resources available for the construction, wider limits of environmental conditions may have to be accepted. In the early factories of the industrial revolution, concentration on machine efficiency often made noise and dust levels far from ideal for the workforce.

Social expectation is often now embodied in law to ensure clients make resources available to maintain healthy and safe environments within their buildings. Many regulations and advisory standards now set design limits for comfortable, safe and healthy environments.

Establishing external design conditions

Establishing external conditions, both climatic and social, is clearly a different task from setting internal conditions. It is necessary to understand the broad patterns of events, with the probability of extreme conditions being identified. The broadest climatic patterns can be identified by global classifications. The fact that the UK lies in a temperate zone gives an overall picture of conditions. However, regional and even local conditions may well determine the pattern of variations and extremes. The South-West has the fewest frosts, and the highest winds occur along the west coast of Scotland. Variations also exist between urban and rural areas where the pollution and the modifying influence of existing developments can have a significant effect, an example of which would be traffic noise. All these may influence the orientation of the building on the site and the choice of materials and detailing to ensure the required performance is achieved. This would also be true of the social conditions, indicated by broad patterns such as inner city, suburban or rural classifications. These may give an indication of the social conditions, but often much more local knowledge will be required if the performance of the construction is to be achieved in practice.

The external conditions need to be understood in order to evaluate most aspects of performance. The need to define climate for environmental control is straightforward: temperature variations and sun paths for heating and cooling requirements, rain and wind conditions for weathering to ensure the building remains dry. However, external conditions also need to be known for structural performance and for durability. Both snow and wind place loads on the building structure but in different ways: sunlight fades colours and embrittles plastics; saturated bricks subjected to frost may disrupt under the internal pressures created during the growth of the ice crystals.

It will be noticed from the above examples that combinations of climatic factors are often the worst design conditions. Wind and rain can be the most testing conditions for water penetration; snow and wind may give the worst loading conditions; wet weather followed by frost causes damage to brickwork. Defining single factors may not reveal the most testing conditions. The pattern and variations in the climate have to be understood well enough to visualise the significant combinations as well as individual extremes.

Establishing variations and extremes requires knowledge of conditions beyond that of the daily cycle or the annual seasons. Extremes do not occur every year but at longer intervals. Some of these seem to be identified with long-term cycles or trends and some seem more random. Since most buildings have design lives measured in decades, cycles, trends and random extremes that happen over these timescales need to be investigated.

For each stage of the analysis (environmental, structural and durability) it is necessary to visualise the most testing set of conditions to maintain performance. For durability this will be dependent on the materials chosen, for the agents of decay are specific to each material. Each set of conditions will then need to be defined in the most appropriate way. Knowledge of annual rainfall gives a broad indication of the magnitude of the problem faced in choosing the construction for a building in that area but it will not give the whole picture. Occurrence

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during the year and some measures of intensity are required. Rain that occurs in a single season of the year at high intensity poses different problems from rain that occurs in light showers throughout the year. Intensity over a period measured in minutes will determine the size of the drainage system, while lower intensity over some hours, particularly if associated with high winds, may determine the detailing of weathering to the walls and roof. In another set of circumstances, prolonged light rain may penetrate porous materials sufficiently to cause dampness on the inside of construction well able to resist a sudden downpour.

While this rainfall example is directly related to the physical climate, the principle of visualising the most testing conditions is true for other performance requirements. Changes in social environments, say with crime and terrorism, also need to be established in some way that allows a design solution to maintain performance of the internal environment even with the perceived levels of threat. Crime figures may allow some quantitative analysis of probability, timing (day or night) and mode of entry, which allows choices to be made as to how best to maintain performance.

Since the external conditions are variable, it becomes a design decision as to which limits are to be taken into account. Generally, design involves establishing the probability of the occurrence and a level of 'value' on the disruption, danger or cost of the consequence of the building failing to perform. Rare but devastating or life-threatening events may be given similar importance to common occurrences that cause inconvenience or a lowering of operational efficiency. It requires the client to assign value to any loss of performance associated with prevailing social and economic conditions. It may also be subject to the law, for in many cases loss of performance poses a danger that the client may not value as highly as society in general. Over the years this has been deemed to be the case with loss of life in a fire and this has led to extensive regulations.

Yet another aspect of the analysis of proposed construction that will require knowledge of the external environment is its manufacture and assembly. Conditions influence the accuracy that can be achieved, leading to variations in the achievable deviations. Protection to both operatives and the partly completed work will be influenced by the condition. Efficiency and hence cost will change with conditions. The way the conditions are defined will again vary, depending on the purpose of the analysis. Number of hours of daylight or frost days per month may now be the most appropriate way to seek the information about the external environment in order to identify the effects on the decision to specify works to be completed on site in the winter.

Social conditions also influence decisions on the production process. The labour market, local, regional, national and even international, has a major influence on the availability of skill and the cost of labour. Site security will be influenced not only by local crime rates but also by legal and social obligations to keep a safe site that protects both operatives and the general public.

Inputs from the activity

For each aspect of the activity, the types of outputs and the quantity of each will have to be established. People within a building will produce varying amounts of heat, moisture vapour, other products of exhalation, odour, etc., depending on the activity being carried out. While some of these may be helpful in, for example, heat gains in winter to maintaining temperature, others will militate against clean air. In another example, the contribution of moisture vapour can have a significant influence on the formation of condensation if ventilation rates are not sufficient. Machines can produce noise and heat and there are concerns over the electromagnetic fields emitted by electronic equipment. While most stored material is inert and contributes nothing to the internal environment, this may not be true if the material stored is organic. Bulk storage of straw can, under some conditions, generate sufficient internal heat to catch fire.

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As with the external environment, broad patterns of these internal contributions may be established, but questions of variations in duration and rates of activity will have to be determined. Designers often look for the single figure to represent inputs from the activity, but if variations are great or change rapidly it may be necessary to analyse the dynamics of the change to match the response of the building more carefully. If data are not available for particular activities, studies will have to be carried out to determine the rate of net inputs into the environment for appropriate construction solutions to be developed.

Inputs from the technical solution

Clearly the effects of the construction and the services cannot be defined before the construction and services are chosen and must, therefore, become part of the process of choice itself. Problems associated with the building in this respect have to be foreseen and minimised at the beginning of the process by the broad strategies developed rather than by resolving problems at the end in the specification and detailing.

Deciding on broad strategies involves decisions on all the performance requirements and is therefore a careful balancing act. This includes the balance between passive construction and the active services. With increased demands for quality in the internal environment with smaller variations, active services are difficult to avoid. Unfortunately it is the services that are most likely to generate outputs that affect the internal conditions and use energy. Some input can be used to advantage. Heat recovery from exhaust air can reduce the size of the heating system and reduce overall energy use. However, the noise from the fans necessary to circulate that air may be transmitted through the ducts. This in turn will require decisions on the use of silencers or sound absorbers in the ducts. The materials for these now have to be chosen with care as fibres from the sound absorption material may be picked up in the air stream and carried to the rooms the ducting system serves. Designs of building that can take advantage of natural ventilation generated by wind and other pressure differences have considerable advantages, but this has to be part of the overall design concept and not a question of detailing.

Most construction materials are inert and therefore add nothing to environmental conditions. Moisture from wet construction at the early stages of occupation of the building has been largely overcome with the use of dry forms of construction.

Choice of interior elements of the building

So far the analysis of internal and external conditions has focused on the inside and outside of the building. However, buildings are rarely used for a single activity. Although there will be an overall purpose for the building, fulfilling that purpose for the user will almost certainly involve a series of interrelated but separate activities. In specifying internal elements, floors and partitions, in the building the notion of an external environment may refer to another internal space used for a separate activity. In this case the internal/external labels are interchangeable.

Problems posed for the construction to solve will depend upon which way the undesirable elements of one environment will affect the second. The task of the construction depends upon which way the flow disturbing the desired conditions will take place. It may become the task of an internal partition to modify sound transmission in one direction and heat in the other if it is between an unheated factory area and an office.

Inside the construction itself

Although apparently not of immediate interest to the user, the process of modifications of environments across construction creates intermediate or micro climates within the construction itself. They can become highly significant to the

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running cost or life expectancy of the construction and that is clearly the concern of the building user or operator. Perhaps the best example of this is the formation of interstitial condensation causing damp when it is apparently dry on both sides of the wall or roof. The wetting of insulation will immediately reduce its effectiveness and, if persistent, may create the condition for rot or corrosion, leading to premature failure.

The analysis of these intermediate conditions that rarely reach steady state is another task for the technologist seeking to provide satisfactory, continuing performance throughout the range of environmental conditions that may prevail.

Summary

1. Building is concerned with providing physical construction to create environmental conditions within the building that are modifications of those prevailing externally. These modifications are required to fulfil both physical and social functions.
2. In providing physical construction, the building will have an impact on both the physical and social environments and these must be understood and be part of the analysis.
3. Both a target value and an acceptable range have to be identified for a number of parameters to define the internal conditions to ensure a comfortable, healthy and safe environment. These will depend on the activities being carried out in the building.
4. The activities within the building generate inputs that will modify the internal conditions. If these inputs take these conditions outside the desired range, the building will have to provide the necessary control to maintain the required internal environment.
5. Under operational conditions the interplay between changing external conditions and inputs from the activities and the construction itself must be seen as a dynamic system: a series of flows seeking equilibrium.
6. In addition to understanding how internal conditions are to be maintained it is important to understand how the choice of solutions will impact on the environment in general.
7. Defining the external conditions, both climatic and man-made, is necessary not only for the environmental modification role of the construction but also because it loads the structure and deteriorates the materials of which the construction is made.
8. Because external conditions influence so many aspects of the analysis of a proposed solution, the same aspect of climate, say rainfall, may have to be defined in a number of ways depending on which part of the analysis of a solution is being carried out. Aspects of climate are also important when deciding on appropriate methods of manufacture and assembly.
9. Internal elements of construction often separate areas of different activity requiring different internal conditions. In this case the definition of the external environment is another but different set of internal conditions.
10. When modifying environments, the construction has different conditions on either side, which means that the conditions within the construction are neither internal nor external. Identifying what the micro environment is within the construction and its rate of response to change will have to be analysed.

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