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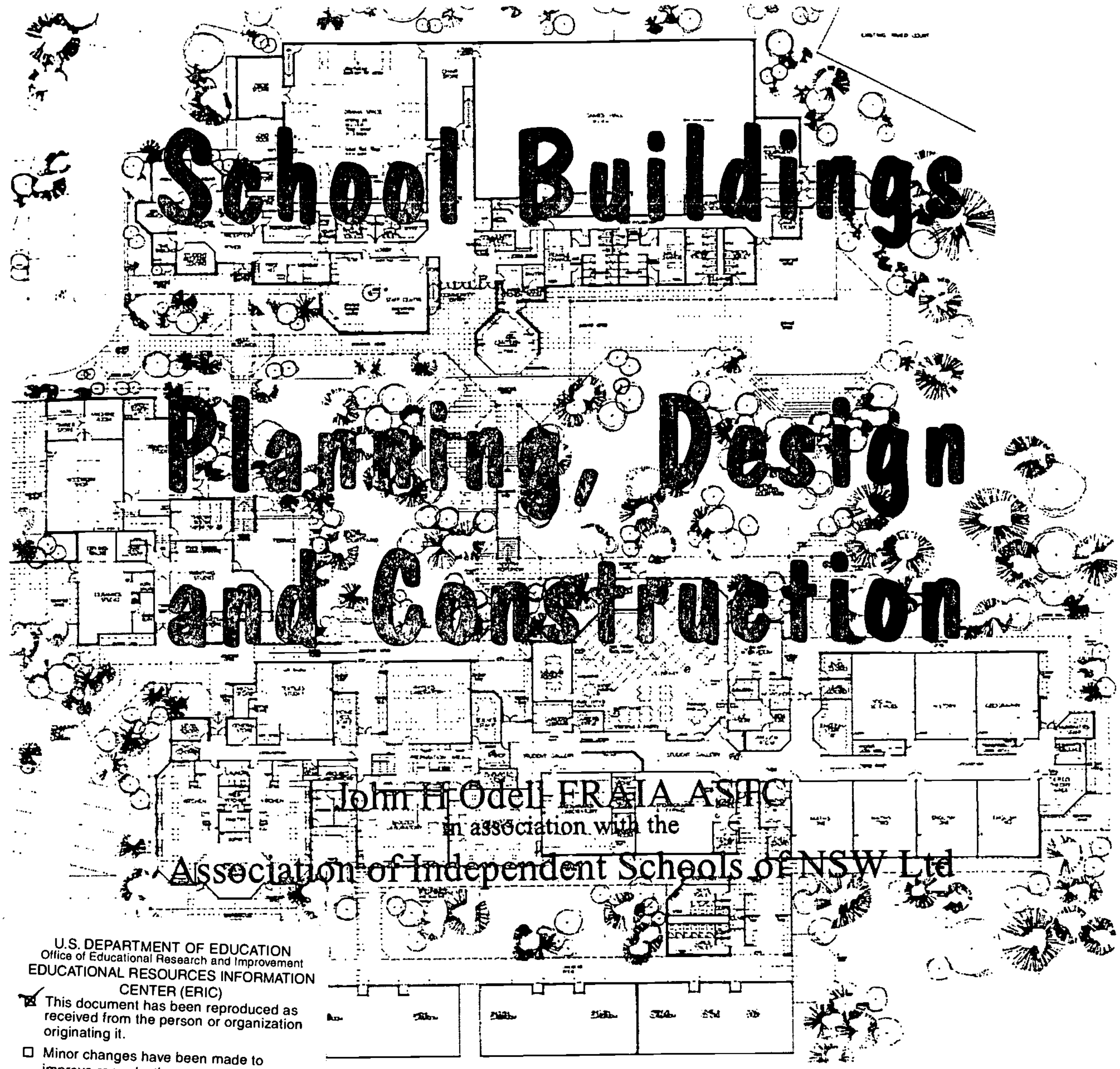
ABSTRACT

A school construction guide offers key personnel in school development projects information on the complex task of master planning and construction of schools in Australia. This chapter of the guide provides advice on the various types of construction that may be used, the materials available, and some elementary aspects of the services required in a school building. Specific topics discussed include Australian building regulations; environmental considerations such as construction for wind and snow or extreme temperatures; cost considerations for internal walls; construction material durability, fire risk, acoustic performance, and sound and heat insulation. The chapter's final sections examine building services and systems essential to schools, including electrical and plumbing systems, emergency lighting and warning systems, lifts and hoists, climate control, and data transfer and security systems. (GR)



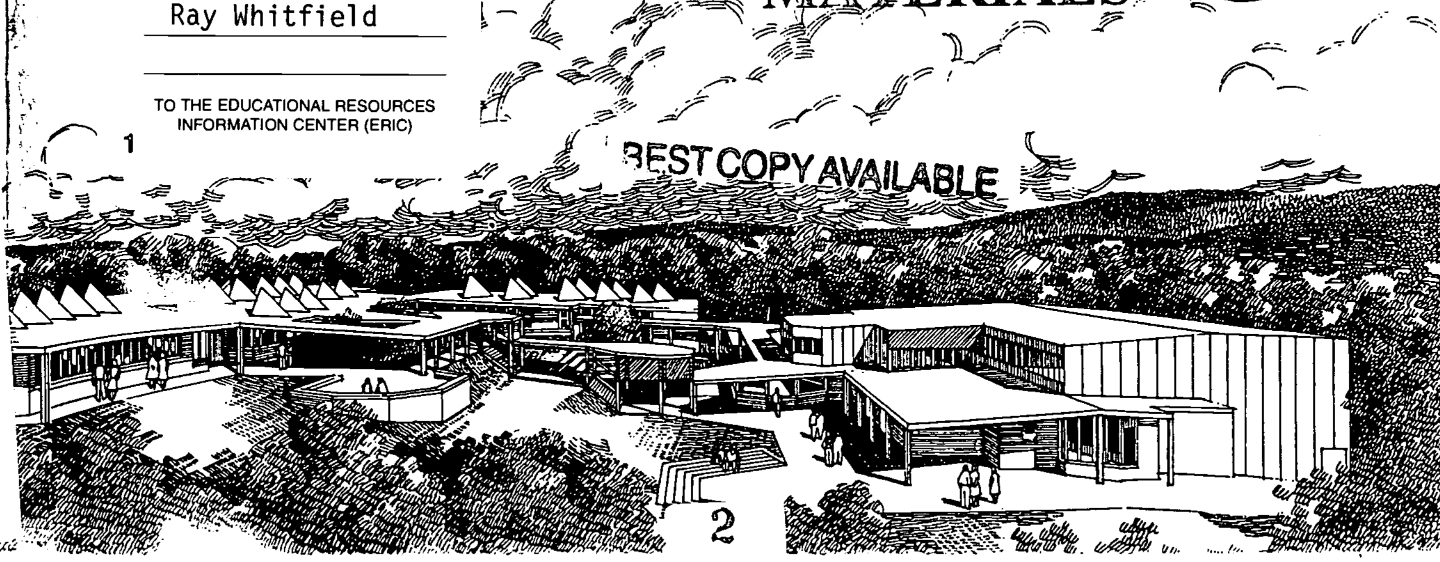
# School Buildings Planning, Design and Construction

John H Odell FRAIA ASTC
in association with the
Association of Independent Schools of NSW Ltd



## CONSTRUCTION METHODS AND MATERIALS 5





School Buildings, Planning Design and Construction is presented in a ring binder with 8 booklets. The document is available only as a complete set

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|---|---|
| 1 | Introduction and Chapter 1 – Developing a Master Plan |
| 2 | Chapter 2 – Making the Most of Your School Site |
| 3 | Chapter 3 – Principles of Good School Building Design |
| 4 | Chapter 4 – Purpose Designed Facilities |
| 5 | Chapter 5 – Construction Methods and Materials |
| 6 | Chapter 6 – Managing the Construction Process |
| 7 | Chapters 7 and 8 – Technology and Managing Buildings |
| 8 | Appendices |

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# A Guide Document

***for School Councils, Boards and Committees, School Principals and Staff and Construction Professionals***

Author - John H Odell FRAIA ASTC

## Introduction to

## School Buildings – Planning, Design and Construction

Good school buildings do not just happen. Thought and consideration must be given to the needs of the users of the building and to the available resources. The persons responsible for building the school should have considerable experience or draw on the advice of those who have.

For a building to be satisfying and successful it must provide shelter, have durable construction and finishes, be aesthetically pleasing and appropriate to its use. A well-planned school will incorporate the following points:

- buildings and grounds will satisfy and support both short and long-term requirements
- curriculum demands including requirements for registration by authorities will be met
- site development will not be haphazard and each project will pave the way for the next
- building design will be flexible to cater for as yet unknown future requirements
- building will be cost effective - and in the long term the school will avoid unnecessary expensive recovery action
- good building design will encourage a high quality educational environment
- pre-planning of maintenance requirements will assist in reducing operating costs

This guide is designed to assist key personnel in school development projects with the complex task of master planning and construction of schools.

Individual chapters in this guide may be distributed to relevant key personnel as appropriate to their specific interest and responsibility.

Each chapter is a separate booklet with chapters 7 and 8 bound together in one booklet and chapter 9 in booklet 8.

The chapters:


1 Developing a Master Plan for Your School

2 Making the Most of Your School Site

3 Principles of Good School Building Design

4 Purpose Designed Facilities

5 Construction Methods and Materials

6 Managing the Construction Process

7 Technology and Educational Buildings

8 Managing School Buildings

9 Appendices


**This Guide aims to:**

- demonstrate the necessity for school communities to produce comprehensive master plans for the development of their school
- encourage school staff and boards to be involved in the development of school facilities and to draw on the wider experience of the community during that process
- outline planning processes and techniques that will lead to greater creativity in school design with greater efficiencies and productivity in the construction process
- help school staff and board members in their dealings with professionals in the building industry, and vice versa
- encourage excellence in school facilities
- maximise potential of limited resources to achieve desirable outcomes
- provide advice on how to determine whether a particular facility is vital to a school
- provide examples of excellence in school building and planning
- provide a comprehensive list of contacts, resources and references.

**Who should read this Guide:**

- All school council/board members
- Principals, bursars and other key staff members
- All members of school building and planning committees
- Administrators in control of school building projects
- Construction industry professionals, especially school architects

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# 5 Construction Methods and Materials

## 5. Construction Methods and Materials

The aim of this chapter is to assist the planning team in understanding the various types of construction that may be used, the materials available and some elementary aspects of the services required in a school building. The term "services" refers to the systems of the building, such as energy for power and light, ventilation and air-conditioning, water, sewerage and security. The sections covered are:

- Construction methods (5.1)
- Choice of materials (5.2)
- Building services and systems (5.3)

**Relevance to Master Planning Team**

While most of the above decisions will be largely the responsibility of the professional consultants (architects and engineers) the Master Planning Team should have a basic understanding of the range of decisions to be made.

Choice of construction method, materials and services needs to be considered in the light of function and economy (however the cheapest solution is not necessarily the most economical in the long run). Different solutions will suit different environments.

> *....understanding various types of construction, the suitability of various material and building services.....*

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## 5.1. Construction Methods

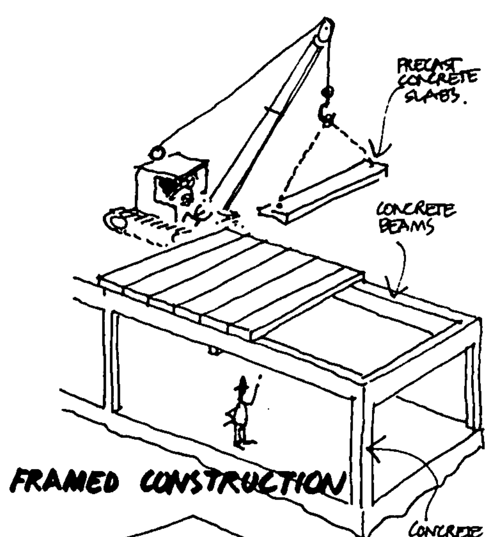
The kind of construction employed is affected by building regulations, environmental conditions, degree of flexibility required along with cost and time factors. This section covers:

- the various types of construction appropriate for use in schools (5.1.1)
- regulations governing school buildings (5.1.2)
- types of construction suited to climate and environment, external and internal (5.1.3)
- building schools that are adaptable and able to be changed (5.1.4)

### 5.1.1. Types of Construction

This section is intended for members of the planning team who lack knowledge of the various kinds of construction. There are essentially three kinds of construction used in schools:

- framed
- load bearing walls
- prefabricated



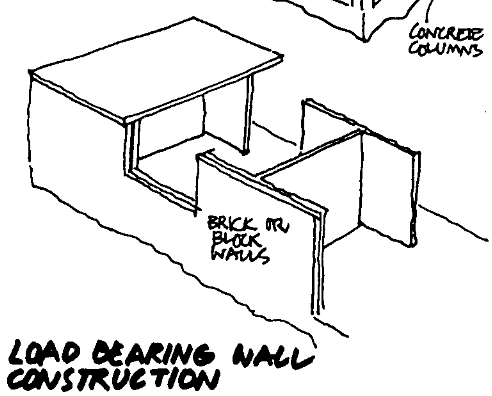

#### Framed Construction

Where floors and roofs as well as walls are supported on a frame of some kind for example steel or concrete columns and beams this is referred to as framed construction.

The structural floors are usually reinforced-concrete slabs or steel floor panels or pans supported by beams with concrete laid in them.

The frame is most likely to be made of steel or reinforced concrete. The materials used will depend on building code requirements applying to the particular situation.

This kind of construction usually provides maximum flexibility provided the spacing of the supporting columns allows the kind of spaces for classrooms.




#### Load Bearing Wall Construction

This is where the walls are designed to carry the load of structures such as an additional floor or roof. Walls carrying the load of floors above are usually brick or concrete block. In the kind of construction to be used in schools the building codes do not permit timber-framed walls to carry loads other than roofs.

When considering altering existing buildings, the function of walls needs to be carefully evaluated before any wall is removed. Walls carrying loads can be sometimes be moved if an alternate structure is provided, such as a beam, or if the load is transferred to another part of the building in some other way.

#### Prefabricated Construction

The classrooms are fully or partly constructed away from the school site and brought to the school in a state almost ready for use. The principle advantage is that it avoids weather delays. Access for the heavy vehicles involved in transporting them to site as well as the lifting equipment is sometimes a constraint.

When preparing budgets ensure that all infrastructure costs are taken into account, such as paths, services, transport, foundations and the like.

### 5.1.2. Building Regulations

NO BUILDING work should commence without formal approval. Some cases in which approval has been assumed and work commenced have resulted in councils requiring demolition of any work done prior to the issue of formal approval documents.

**Building Code of Australia (BCA)**

The most significant and least flexible building regulations of those governing schools are those regulations incorporated in the relatively new BCA. The BCA applies throughout Australia, although some aspects of the code reflect particular state requirements. The BCA covers matters such as:

- fire resisting construction
- means of egress, widths, maximum distance of travel
- dimensions of stairs
- emergency lighting
- light and ventilation requirements
- room size, ceiling heights
- toilet and washroom facilities
- food services areas

The BCA is administered by local shire and municipal councils through the following processes:

**Development Approval (DA)**

DA is primarily concerned with planning approval. The main issues considered include:

- zoning
- transport, vehicular movements, buses
- impact on neighbours, noise, shadows, aesthetic
- outside appearance of the buildings
- landscaping

To apply for DA, a school should submit to council its complete Master Plan including long-term requirements (and not just the immediate first stage). The DA, in principle, is for the school's total development. DA can take many months if sensitive issues are involved. DA's can be varied by application to Council.

**Building Approval (BA)**

BA is required from local council for the construction of a particular building. BA is primarily concerned with construction methods, fire risk, health and safety issues, distances from boundaries and room sizes. Obtaining a BA can take months. Support documents must be submitted including:

- drawings and specifications

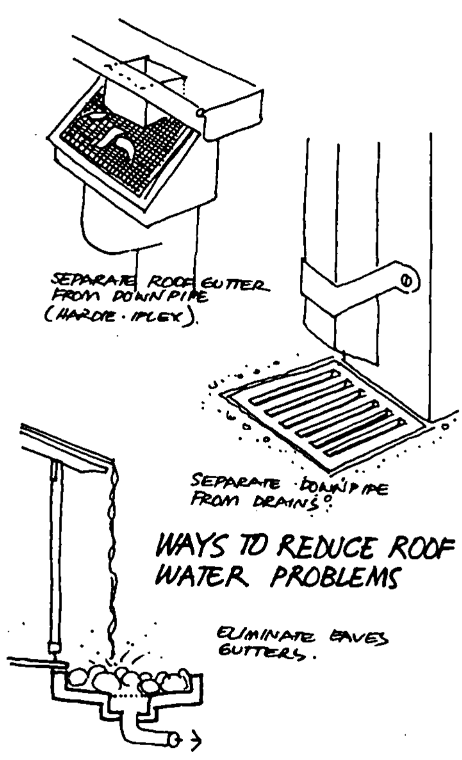
- structural engineering drawings and design calculations
- mechanical services (air-conditioning and ventilation equipment)
- drainage and water supply systems
- emergency lighting systems
- fire fighting systems

**Other organisations that regulate school buildings**

- fire brigade
- water supply authorities
- gas supply authorities
- electricity supply authorities
- education authorities
- state government

Each state will have variants of the Building Code of Australia, though these are being progressively reduced. Similarly local authorities will impact on school buildings in different ways. For example in South Australia there have been "trade-offs" as regards fire fighting equipment. The usual fire services are rationalised in exchange for counter-balancing safety measures, the rationale being that teachers not used to fire-fighting equipment are better utilised in the safety and well-being of the children.

The school's planning committee needs to make a careful assessment of the approval procedures required at an early stage of the project and make adequate time allowance for all approvals.




### 5.1.3. Environmental Considerations

The environment has an impact on the way a school is to be designed and built. Aspects of the environment affecting design and construction methods include:

- general weather factors
- city, suburban or rural factors
- socio-economic nature of locality

**Weather factors**

School buildings need to provide shelter from rain, wind, extremes in temperature and, in some locations, snow and sleet.

***Construction for rain***

Heavy rain requires:

- large roof gutters and downpipes (consider ways to alleviate blockage by leaves and other debris)
- an alternative to roof gutters is no gutters with appropriate protection of the ground below to prevent scouring of the ground and above door openings to shelter people
- significant slope in paving

- large drain pits and ground drainage pipes
- sheltered areas adjacent to play areas

Persistent light rain requires:

- covered walkways between buildings or buildings that are totally enclosed
- areas for storage of wet weather clothing and umbrellas, preferably drained

### *Construction for wind*

In areas where there are strong winds schools need to consider:

- doors and windows that are well sealed when closed to prevent disruption by noise of wind
- sufficiently strong door closers
- roofs and walls that can withstand fierce winds
- outdoor shelter for students. A solid wall may be less effective than a perforated wall
- heavier ceiling tiles or tiles with clips where suspended ceilings are specified; or alternatives to suspended ceilings. Tiles in suspended ceiling grids can sometimes lift in high wind.

### *Construction for snow*

Snow and sleet are problems in very few Australian schools. In these areas, schools should require that:

- access ways are free from snow falling off roofs
- paths are constructed so that they do not ice up
- snow is cleared from exits and entrances
- roofs are strong enough to withstand expected snow loads

### *Kinds of construction for extremes of temperature*

The most significant weather factor to be considered is temperature extremes. Depending on the type of climate, lightweight or heavy construction can be chosen after weighing the advantages against the disadvantages.

- Lightweight construction is framing covered with thin materials such as fibre-cement sheeting or formed-steel panels
- Heavy construction means brick, stone or concrete walls.

Lightweight construction can be used in environments where conditions are mild or where insulation can overcome the extremes of temperature.

**advantages**

- does not retain heat - ideal where breezes can alleviate hot weather
- generally cheaper than heavy construction
- relatively easy to change if rearrangement of space is required

**disadvantages**

- difficult to insulate for extremes of temperature
- difficult to isolate acoustically - noise travels between rooms both through walls and through floor construction
- more easily damaged than heavy construction

**Heavy Construction** can be used where temperatures are high and buildings are likely to be unoccupied at night. For the reason that during the day, the heavy masonry (brick, stone, concrete) absorbs the heat (functions as a "heat sink") and re-radiates during the night. Under these conditions, the heat must be able to radiate to the outside, that is, the space must be well-ventilated.

Heavy construction might also be used in very cold environments provided appropriate insulation is used to retain heat inside.

**advantages**

- good resistance to damage
- in cold environments, retains heat and re-radiates it (stabilises environment)
- in hot environments, functions as heat sink (suitable if ventilation allows dissipation at night, when building is unoccupied)

**disadvantages**

- difficult to repair damage when it does occur
- not suitable where ventilation does not provide for dissipation of heat after hours
- difficult to modify if change is required

**Impact of city locations on construction**

A school to be built in the city will generally be required to conform to higher standards of construction in terms of durability and weather resistance. Maintenance standards will be higher. Resistance to vandalism may have to be higher than in the suburbs.

Conformity to design standards, to planning schemes and provision for servicing are also likely to require greater expenditure than in the suburbs or in a rural environment.

**Socio-economic nature of locality**

If a school is to have relevance to the community it serves, it needs to adopt similar standards of design, planning and material selection to that generally applicable in the community.

A school drawing from a rural community used to an agricultural lifestyle should reflect this aspect in the choice of materials most common in that area. A school in a highly industrialised or business-oriented area would reflect planning approaches and design standards compatible with that community.

### 5.1.4. Constructing for flexibility

Flexibility in design should be one of the primary aims in designing school buildings in view of the current educational climate. Changes to curriculum, methods of teaching, class structure arrangements, retention rates and technology have placed an increasing demand on planners to design "flexible" schools, i.e. schools that can be changed/adapted as demands change.

The choice of construction method will have a significant impact on the degree to which a building can be adapted and modified. In design terms the greatest constraints on flexibility are:

- foundations
- services
- external walls
- roofs
- other buildings.

Therefore these aspects of design must be carefully considered initially.

Generally only the internal walls can be modified. Internal walls constructed from brick or concrete masonry are difficult, messy and costly to remove and replace. Where they are also used as structural supports for roofing or floors the limitations are even greater. On the other hand, framed and sheeted walls (e.g. plasterboard on lightweight steel framing) is relatively inexpensive to move. These walls are not used for load bearing purposes but, in certain cases, may be used to support ceiling framing.

Other design alternatives which provide flexibility:

- timber framed walls sheeted with chipboard or plywood sheeting
- transportable walls - supported on tracks hung from the ceiling or roof framing
- demountable walls or partitioning

**Cost considerations for internal walls**

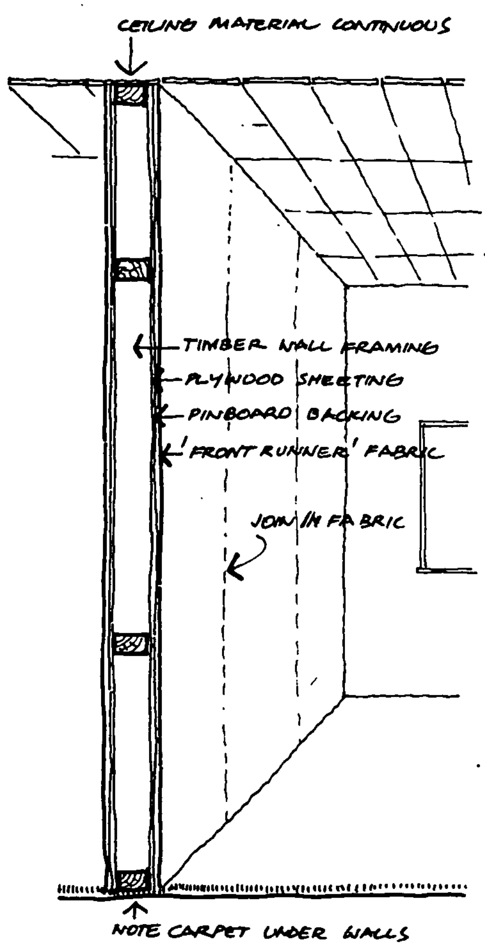
Construction methods ranked in order of cost (the cheapest listed first):

- metal-framed walls sheeted with plasterboard
- timber-framed walls sheeted with chipboard
- demountable walls or partitioning
- masonry walls
- transportable walls

Construction methods ranked in order of ease of change (easiest and cleanest listed first)

- transportable walls

- demountable walls or partitioning
- timber-framed walls sheeted with chipboard
- metal-framed walls sheeted with plasterboard
- masonry walls




Construction methods ranked in order of potential for reuse of materials (though not necessarily the cheapest when labour is considered in the cost analysis) - most convenient and highest reuse first:

- transportable walls
- demountable walls or partitioning
- timber-framed walls sheeted with chipboard
- metal-framed walls sheeted with plasterboard
- masonry walls

**Some examples:**

***Timber-framed walls: Plenty Valley Christian School - located north of Melbourne, rural Victoria***

All internal walls are constructed of timber framing, sheeted with chipboard and pinboard base covered with "Front runner" a melded fabric ideal for wall covering. Architect was Paul Archibald.[1]

**advantages**

- most of the material can be reused
- there is no painting of internal walls, reducing maintenance significantly
- changes can be made in a very short space of time
- deterioration rate of wall finishes is very low - does not show scuffing marks

**disadvantages**

- initial cost was higher (but in long term is regarded as being cheaper)
- reverberation time in room is very low (not a significant issue and can be an advantage)

***Metal-framed walls: Pacific Hills Christian School - Dural, outer suburb of Sydney NSW***

Most of the internal walls are metal-framed sheeted with plasterboard, set and painted. The walls are non-loadbearing, the roof is supported on steel columns and beams, the columns being sufficiently spaced to give adequate flexibility in locating walls. Several changes have been made demonstrating the benefits.

**advantages**

- ease of making changes

[1] *Paul Archibald Pty Ltd Architects 2a Milne Rd. Box Hill North, Vic Phone (03) 899 1088*

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- easy to maintain
- relatively low initial cost

disadvantages

- easily damaged - can be overcome with tougher finishes such as timber boarding or carpet at low levels
- sound travels through walls - needed acoustic insulation (note - fibreglass not suitable, use material specifically appropriate for sound isolation)

***Transportable walls***

These are panels, usually around 90cm wide and extending full-height to the ceiling. The panels are usually well designed acoustically with adequate density and acoustic seals at floor and ceiling and between each panel.

The panels are supported on tracks hung from firmly supported and substantial steel framework. For adequate acoustic isolation between rooms it is important to install an acoustic baffle between the ceiling and the roof or floor above.

If the intention is to make one larger space from two or three classrooms by opening up doors, ensure that the door panels are full height to the ceiling. If door panels are normal door height the room acoustics will be poor - it will not be easy to project the voice from one end to the other without significant amplification. The fixed panel above the doors will act as a barrier.

advantages

- maximum flexibility
- good acoustic isolation if properly constructed

disadvantages

- expensive
- the acoustic benefits deteriorate due to changes in surrounding structure, e.g. the floor slab sags, the seals become damaged. This can be overcome at the top of doors by providing for some adjustment.
- heavy for students to move and, if not carefully handled, can be damaged

## 5.2. Materials and Hardware

This section covers materials selection as to appropriateness, durability, repairability, maintainability, reusability and cost effectiveness. Given the wear and tear schools receive from a continuous influx of students, materials and hardware choices require careful consideration. In addition there are factors pertaining to functional use and performance. For example, a room used for music rehearsals requires a high level of sound absorption, while a performance area requires a degree of reverberation or resonance. The surfaces to achieve these conditions will be quite different.

The following factors influencing choice of materials and hardware for use in a school building are examined in this section:

- durability (5.2.1)
- weather resistance (5.2.2)
- resistance to vandalism (5.2.3)
- aesthetics (5.2.4)
- cost (5.2.5)
- cleaning costs (5.2.6)
- re-use potential (5.2.7)
- fire-risk (5.2.8)
- acoustic performance (5.2.9)
- acoustic and heat insulation (5.2.10)
- resistance to chemicals (5.2.11)
- repairability (5.2.12)
- light reflectance and glare factors (5.2.13)
- adaptability (5.2.14)
- materials appropriate to the environment (5.2.15)

In most cases, more than one characteristic must be considered, often involving compromise. For example, if durability is considered a high priority, a very durable floor surface may be considered, such as polished or steel-trowelled concrete. This type of surface, however, has a number of negative characteristics such as: slippery when wet, highly reflective acoustically and unattractive colour. If the negative factors can be overcome, the overall benefits of the cheaper solution may make this selection an acceptable floor finish. Otherwise a surface less durable may have to be selected to achieve other characteristics.

An excellent guide to materials suitable for use in schools was produced by the Commonwealth Schools Commission in 1982 called "Comparative suitability of materials for use in Australian schools". This publication is no longer in print, but copies may sometimes be found on the shelves of established schools or at the local Block Grants Authority Office.

### 5.2.1. Durability

Durability is the capacity of a material to resist wear and tear. Durability needs some consideration as regards the approach the designers are to take. For example: is the approach to be low initial cost and high replacement cost or high initial cost and low replacement costs? Is the area vulnerable to vandalism? Is the school likely to cater for students who care? Will high quality finishes enhance or encourage a caring response or will they be ignored?

Areas requiring high durability include:

- paving and walls in high pedestrian traffic areas
- areas exposed to impact from balls, school bags, equipment trolleys and cleaning equipment

Durable materials include:

- Concrete. Concrete when used as paving needs to have a coarse, ribbed or textured finish. This can be achieved for example by spraying with water prior to it setting to expose the aggregate or dragging a course broom across it prior to setting. Concrete and brick, when used as wall finishes, must be sealed in some way. These kinds of finishes are difficult to repair in a seamless fashion - the patch is difficult to conceal.
- Brick. Only sufficiently hard bricks (hard usually as a result of longer firing in the kiln) should be used for paths and paving.
- Ceramic or terra cotta tiles. Only ceramic tiles with a non-slip finish should be selected for floors. Ceramic is probably the best wall material but is very expensive and usually used in wet areas only, such as washrooms, toilets and cooking areas.
- Compressed fibre cement used as a wall surface, roof fascia material with a colour coating or as a floor with a floor finish such as ceramic or vinyl tiles.
- Hardwood is well-known as a flooring material which, with appropriate finishing, is suitable for school use.

These materials can be used as both floor and wall finishes although not all of them are equally suitable as a floor finish.

Other aspects of durability pertain to impact and vibration from slamming doors and windows, wear and excessive force on door handles and hinges, student "testing the strength" of materials and fittings, and the ability of fixings such as screws and bolts to resist unauthorised removal or vandalism.

### 5.2.2. Weather resistance

Weather affects buildings in the following ways:

- rain penetration
- grime becoming embedded with the rain as in stone or concrete and brick masonry
- frost damage in colder climates,
- expansion and contraction in hot climates

A moisture-resistant external surface may be achieved in ways such as:

- masonry wall with two skins - this is called cavity construction
- materials impervious to water
- roof overhangs; protecting the surface from rain impact

### 5.2.3. Resistance to Vandalism

Materials that minimise vandalism are increasing in importance. A significant portion of the maintenance budget may have to be allocated to this purpose. Some constructive solutions to this problem are as follows:

- strategically placed fences, general building layout and plant screening of walls to make external surfaces less exposed or inaccessible
- use of materials that are not easily damaged or that do not provide an appropriate surface. A highly texture surface deters graffiti as the writing is difficult to read – effective because recognition seems to be important to vandals in their choice of surfaces to deface
- treating surfaces – there are a variety of proprietary applied finishes, some transparent, that are vandal-resistant.[1]

### 5.2.4. Aesthetics

Aesthetics pertain to juxtaposition of materials to achieve a balance and harmony of colour and textures. Materials chosen for their natural colour (e.g. bricks) are usually preferable to applied finishes such as paint. This principle applies unless the material, such as plasterboard, requires a paint finish.

Avoid choosing an applied finish that is less durable that the surface to which it is being applied. Painted face brickwork fails this principle. There may be a case for painting concrete, although it is highly durable, due to the difficulty in achieving consistent colour throughout as variation in drying time affects colour.

Another important factor is the durability of a material – the longer it resists damage and grime, the longer it will retain its inherent aesthetic appeal.

### 5.2.5. Cost considerations

The initial cost of the material should be compared with its maintenance cost to the end of its useful life. If an alternative material produces a lower life cycle cost outcome, then it should be used, unless initial costs must be kept low for a particular reason. If in doubt, initiate a life-cycle analysis of the material.

Quite often short-term savings on cheaper materials are offset by increased repair and maintenance bills in the long term. A classic example is the use of glass doors in secondary school corridors. If the glass is broken frequently, and eventually has to be replaced by poly-carbonate sheet (much more expensive than glass but far more durable) then the initial expense can be justified not only in reducing the cost of the repairs, but also, the time and effort of school staff in arranging the repairs and disciplining the students.

The following factors influence the cost of materials:

- transport costs (transporting materials from areas far from their source or place of manufacture will increase costs)
- large areas of application (i.e. high-volume purchase of the material) will usually result in lower unit cost, conversely small areas (i.e. low-volume purchases) will result in higher unit cost
- demand-driven prices – in periods of low building activity, prices decrease, conversely high activity (resulting from high demand) drives up prices

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1 *Refer Appendix 9.11 for A list of Anti-graffiti products*

### 5.2.6. Cleaning Costs

The planning team should formulate a general policy with respect to cleaning: whether building materials should be chosen to keep initial costs low (usually resulting in high cleaning and maintenance costs) or whether initial costs may be high (to minimise cleaning and maintenance costs).

A life-cycle cost study should be made of all significant materials, particularly floors. This study should also include an analysis of all maintenance and replacement costs. For example a vinyl sheet floor may be cheaper both in terms of initial cost and wear replacement costs (vinyl floors have a long life). However, the cost of cleaning vinyl, including regular stripping, repolishing and buffing can far outweigh the cost of cleaning carpet. Life-cycle costings may well indicate that carpet is less expensive than vinyl sheeting.

LIFE CYCLE COSTING
BASED ON 100 SQ M

| | MATERIAL CARPET | VINYL TILES |
|---|---|---|
| INITIAL COST | 3579 | 2200 |
| USEFUL LIFE | 10 YRS | 15 YRS |
| PER ANNUM COSTS | | |
| CAPITAL | 358 | 147 |
| CLEANING VACUUM 1X DAY | 900 | |
| SWEEP/MOP 1X DAY + BUFF 1 X WEEK | | 1800 |
| STRIP/POLISH 3X YR | | 600 |
| | $1258 | $2547 |

### 5.2.7. Reuse Potential

Reuse potential is of minor importance to school planners, however it is worthy of discussion since it may have a bearing on material choice and on longer term planning. Reuse potential is relevant to schools in the initial stages of development where buildings have to be modified as the school grows.

Plywood, particle board and panels of polyurethane foam with sheet metal or fibreboard are reusable materials, but reuse potential depends as much on fixings and joining methods as on the material itself. Modular window walls of aluminium framing, folding walls, doors and windows are other building materials which may be reused.

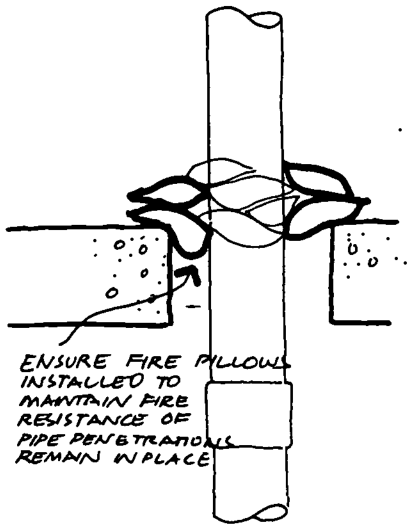
Just because a material can be reused does not mean it is the most economical. Reuse may involve greater cost than using new materials.

Keys to maximising reuse potential are:

- modular planning (based on a grid so that elements fit wherever they may be placed)
- consistency throughout the building in room sizes, finishes and construction
- planned approach to the level of reuse of materials intended so that designers can act accordingly
- care with the way materials are joined and fixed so that demounting these materials and building elements can be achieved with minimum damage.

### 5.2.8. Fire-Risk

Fire hazard is among the greatest threats to safety in school buildings. Hence, the importance of fire safety in the building codes and to the relevant authorities. The Building Code of Australia




(BCA) refers to two aspects of materials in relation to fire. These are:

- flammability index
- spread of flame index

They are also described in detail in Australian Standards AS 1530. They pertain to the degree to which materials ignite or spread flame. A material may ignite, but burn slowly and not spread flame (e.g. wool carpet). The materials used should burn with a minimum of toxic gases and smoke. Confined areas such as stairs and fire escape passages must remain free of hazardous gases for specified times. It is best to leave consideration of these aspects to professional building consultants or builders with experience in these matters.

The fire zone in which the school is located will determine the degree to which these standards and requirements apply. For example, a school in a high-risk fire zone will require higher levels of fire resistance than a school in a lower-risk fire zone.

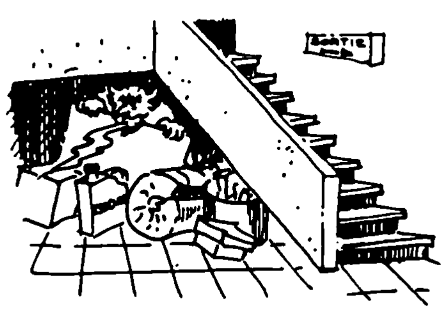
Walls near a boundary or isolating a fire escape are required to have a higher fire resistance than other areas of a building. A specially formulated mulched paper with additives to reduce flammability to safe levels can be sprayed on to ceilings and high walls.

There are other requirements pertaining to the capacity of various parts of a building to resist fire. The capacity of a construction to resist fire is expressed in three ways:

- structural adequacy
- integrity
- insulation potential

In the BCA, structural adequacy specifications are given in the following form, 90/60/60, which means that the material:

- is capable of resisting fire and remaining structurally adequate, i.e., it will continue to do what it was designed to do for 1.5 hours (structural adequacy)
- will not fracture and let flame through for 1 hour (integrity)
- will satisfactorily isolate the area on the other side of the material from unacceptable heat for 1 hour (insulation potential).



BUILDING CODES FORBID STORAGE OF ANY KIND IN FIRE ESCAPES & STAIRS

The purpose of these requirements is to permit safe egress from the building and sufficient time to access the building to extinguish the fire.

Planning teams must understand these concepts well enough to adequately brief the users of the building in safe management practices, which include:

- banning storage or use of flammable materials in main thoroughfares, especially in designated escape passages and stairwells

- maintaining required signs related to storage and safe passages (noticeboards should not be made of flammable material)
- not using materials likely to emit noxious fumes or smoke which inhibit clear passage for escape

**Doors as Exits**

The Building Code of Australia requires that every door functioning as a required exit be readily opened from inside by a single-handed action without a key. This means that locks cannot be used to secure the door from the inside. To lock the door against egress contravenes regulations and safety. Schools may find security compromised as people left inside the building can open the door at any time after the building is "locked up", leaving the building open to unauthorised entry.

Solutions include:

- use of door closers on such doors
- alarm systems to warn of doors being used after hours
- training programs for staff on security and safety requirements for exit routes
- signs on exits discouraging use after hours and/or
- signs encouraging users to shut doors

State laws vary on these matters, therefore the building design consultants should provide clear direction as to appropriate regulations.

**Required fire isolation enclosures**

Mandatory enclosure of certain spaces to provide safe egress require complete integrity, that is no breaks that will reduce the fire resistance of the enclosing elements (walls, ceilings and floors).

Such spaces should not be altered by construction/services etc. Integrity could be jeopardised if the service itself is flammable (e.g. a gas pipe) or if the holes through which the service passes are left untreated. When penetrations are required, they can be sealed with "fire pillows" or fire-resistant mastic.

Management procedures should be established that require consultation with relevant experts before modifications can be approved.

## 5.2.9. Acoustic Performance

A good aural environment will allow the wanted sounds to dominate the background sounds and will filter out or block unwanted ones. Clear communications rely significantly on dealing effectively with the various aspects of acoustics.

**Noise Levels**

**• Road traffic noise**

For locations adjacent to roads carrying traffic, typical peak ($L_{10}$)[1] and background ($L_{90}$)[2] levels are given in table 1. The levels are based on kerbside measurements — 8.0 m from road centre line.

| Road type | Two way traffic (vehicles/hour) | Peak ($L_{10}$) | Background ($L_{90}$) |
|---|---|---|---|
| Arterial road with heavy traffic | 2000 | dBA 75 | dBA 60 |
| Major roads with medium traffic | 1000 | 70 | 55 |
| Residential roads with medium traffic | 400 | 65 | 50 |
| Minor roads with local traffic | 100 | 60 | 40 |

TABLE 1: TYPICAL NOISE LEVELS FOR ROADS CARRYING TWO WAY TRAFFIC[3]

**• Aircraft noise**

The intermittent nature of aircraft noise makes it difficult to assess which levels cause annoyance in the community. Factors such as type of plane, climb or descent characteristics, power thrust and height above ground level govern both the noise level and its associated degree of annoyance.

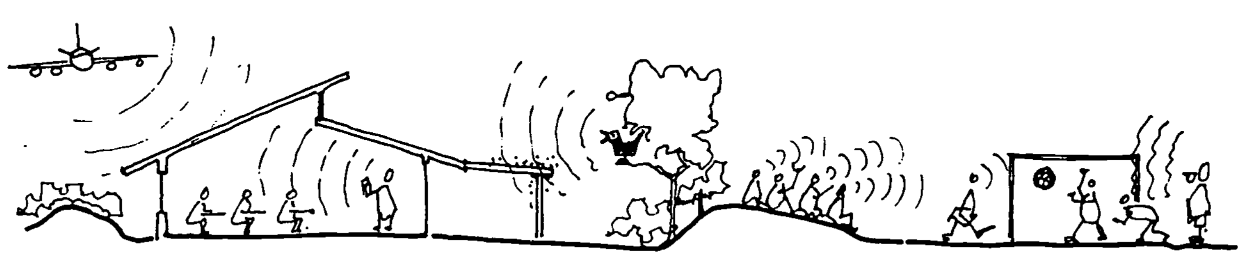
Generally, maximum noise levels of 90dB(A) - 100dB(A) occur along the main flight paths and within ½ km radius of the path. Between a ½ km and 1½ km radius along the paths, these levels decrease to about 80dB(A) - 85dB(A).[4]

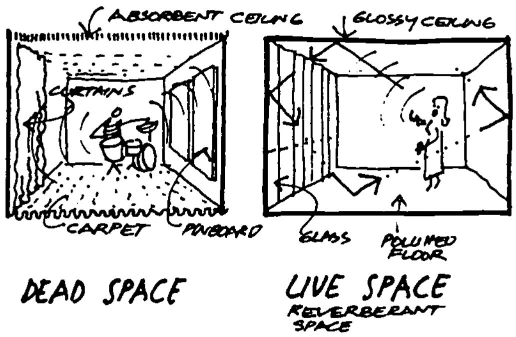
**• Industrial noise**

Community health facilities are not normally located in areas zoned for industrial use. However, industrial noise can be a problem when this zone adjoins a residential or commercial one, or when planning and development exemption has been obtained for the redevelopment of an existing site. For this reason, typical noise levels should be measured prior to the building design.

The maximum permissible average noise level ($L_{eq}$)[5] which can be emitted within a 100 metre radius of most industries, is about 70dB(A).

Information from "Design of Doctor's Surgeries" published by Royal Australian College of General Practitioners

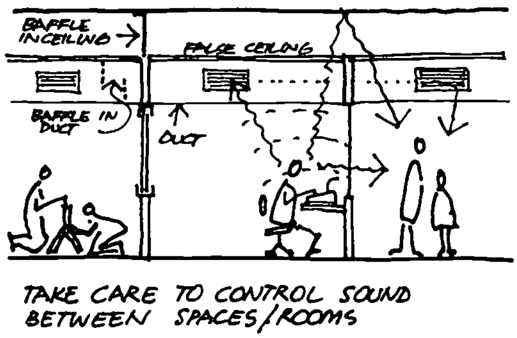





The main requirement for much of a school's acoustics is for the speech spectrum, and this is the easiest to provide. Different spaces produce different levels of reverberation. This quality has to do with the way a room responds to noise. If the sound continues for a long period it is said to have a long reverberation time. Reverberation is different from echo.

**Echo**

Echo is the result of clear sound "bouncing" off a surface in a way that the original sound is reproduced. Echo is to be avoided as it interferes with clarity of communication. Echo produces a "hard edge" to sound and is much less diffuse than reverberation.



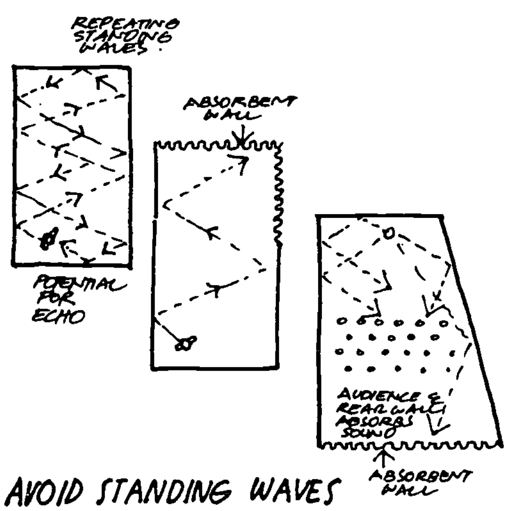

**Reverberation**

Reverberation, to some degree, is desirable. It is much more diffuse than echo and contributes to the production of sounds that are referred to as rich or mellow. The chosen degree of reverberation will depend on the proposed use of the room.

Spaces for musical performance should have long reverberation times. Spaces for drama and speech (classrooms) should have reasonably short reverberation times. But not so short that the space sounds harsh or dead.

Several factors influence echos and reverberation time:

- shape of room
- materials used on the surfaces
- degree of occupancy



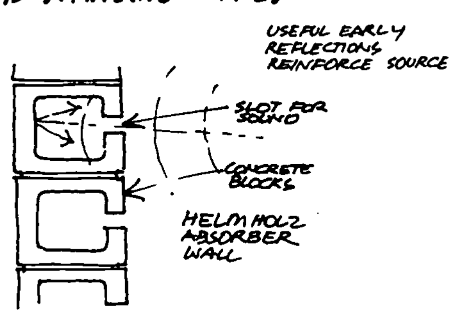

*Shape*

Most large rectangular spaces produce undesirable echos unless walls are specially treated. The reason is that standing sound waves will be created in the room (caused by sound reflected between parallel walls). One possible solution is to change the shape of the room so that walls are not parallel.

*Materials*

Materials that can reduce echo and reverberation include:

- increasing window area (effective only when windows open). A window is the perfect absorber - it is used as the measure of sound absorption in acoustic calculations.
- installing soft material on the floor and on at least one wall. Materials on the walls such as carpet, large areas of curtains, soft fibreboard and acoustic tiles all assist in absorbing sound.
- soft furniture. Soft furniture may help to reduce echo.
- Helmholz absorbers - hollow blocks with slots to "swallow" the sound are sometimes used in spaces such as gymnasiums to reduce sound levels.




The degree to which materials reduce reverberation or echo can be assessed by trained acoustic engineers.

Science rooms are notoriously difficult to manage acoustically due to the preponderance of hard surfaces. Solutions such as squares of carpet in the centre of science laboratories to reduce reverberation and to reduce sound at the source (chair legs scraping on the floor) have been used successfully in a number of schools.

Another solution is to hang acoustic baffles from the ceiling around the room.

In rooms where sophisticated acoustics are required (e.g. music performance) compensating materials can be installed (e.g. curtains drawn across walls) to allow adjustment of the reverberation time.

*Degree of Occupancy*

A room which is full of people will have a shorter reverberation time (less echo) than a room which is empty.

## 5.2.10. Insulating for Heat and Acoustics

There is a great deal of misunderstanding over the insulating value of materials for acoustics and for heat. In this section, sound insulation and heat insulation will be defined and explained.

### Sound insulation

In the section on acoustics above (5.2.9) insulating against reverberation or echo *within* a space was covered. Here, the focus is on insulating against sound travelling from one space to another through walls or doors (usually unacceptable except at low levels).

Contrary to what may be required to reduce sound within a space, namely soft or low density materials, dense materials are the most effective for *isolating* sound to a particular space.

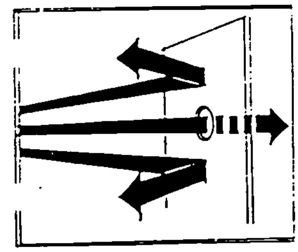
When soft material such as glass fibre batts or dacron blankets are used, their effectiveness relies on cutting down reverberation within the wall cavity. Some of these materials, specifically designed for acoustic isolation, are effective. Choose such materials with care and check carefully with the manufacturer before specifying. Double thickness plasterboard or a similar material may be just as effective.

### Heat Insulation

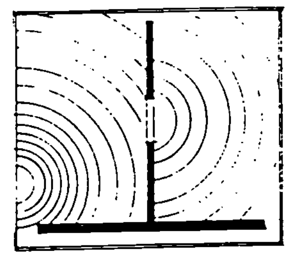
The most effective insulation for retaining heat in a building is material containing static air masses or reducing air-movement within the surrounding walls. Fibreglass and Dacron blankets or batts are usually used for this purpose.

In roofs, locate insulation against the roof surface to reduce drumming of heavy rain as well as to isolate heat at the outer surface of the building. To prevent condensation from forming within the insulation, thus destroying the insulation value, place a moisture barrier of polyethylene film under the insulation, making sure that the seal remains effective at the joining of the materials. Maintenance staff should understand the function of this barrier to ensure that when it is breached (to install other services or for maintenance) the barrier must be restored.

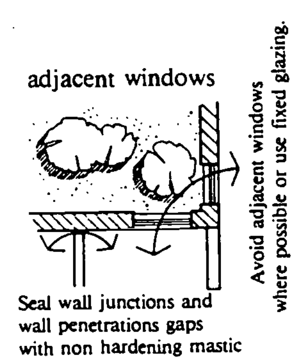
To limit heat coming in to a building some have relied on reflective "sarking" - a building paper with a reflective surface to reflect heat back to the roof surface. This is effective only while the reflective capacity persists - dust and grime quickly destroys its functionality.

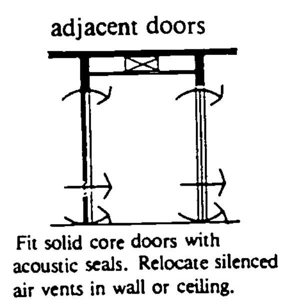


HIGH FREQUENCY SOUND PASSES THROUGH AIR GAPS



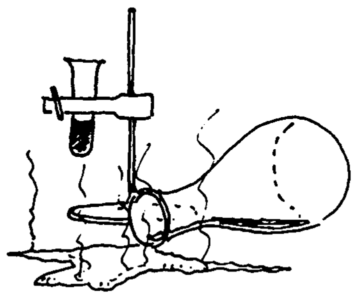
LOW FREQUENCY SOUND RERADIATES FROM AIR GAPS




Illustrations from "Design of Doctor's Surgeries" published by Royal Australian College of General Practitioners

This kind of insulation does nothing to contain heat within a building.



### 5.2.11. Resistance to Chemicals

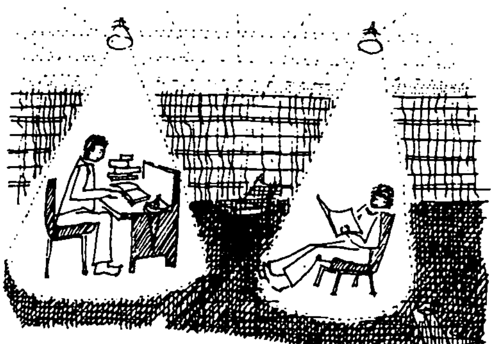
The chemicals used in science rooms, art rooms, materials laboratories and food technology rooms are rarely sufficiently volatile to warrant excessive expenditure on bench and shelf surfaces.

Science areas are more vulnerable to damage from chemicals than are food preparations areas. In both areas, staining is the more likely problem and for this reason alone, chemically resistant surfaces are usually preferred.

There are three ways to provide the required protection, the first two being suitable in food preparation areas only:

- chemical-resistant grade melamine laminate
- full thickness bench top material, AZTEQUE, made by Laminex
- chemical-resistant applied finishes (paints)

The benefits of the latter two are that they are repairable (no surface is completely resistant to accidental or deliberate damage).



Definition and personification of territory using light.

### 5.2.12. Repairability

In selecting materials for use planners should keep in mind:

- the time required for repairs
- the degree to which matching materials is possible
- safety in repair process (no toxic fumes for example)
- the degree to which expertise is required and available (is it better to use a material which can be repaired by a handyman)

### 5.2.13. Light Reflectance and Glare factors

A major activity in schools is reading and work relying on high visual clarity. For this reason designers must give careful attention to lighting both artificial and natural.

Glare results when there is too much contrast between the object of primary interest and the surrounding surfaces. In these circumstances the eyes are required to adapt to the varying intensities too much and tiredness results. This is especially true when the surrounding surfaces are much brighter than the primary object. It is recommended that the following rules be implemented to minimise glare:

- no large area should have a brightness less than one third the task brightness
- no area adjacent to the task should be brighter than three times the brightness of the task
- no area in the visual environment should be brighter than five times the brightness of the task.

**RECOMMENDED ILLUMINANCES**

| | |
|---|---|
| Classroom | 500 LUX |
| Drafting & Graphics | 500 LUX |
| Laboratories | 500 LUX |
| Library Reading | 500 LUX |
| Offices | 500 LUX |
| Shop Area | 500 LUX |
| Typing Rooms | 500 LUX |
| Auditoriums | 250 LUX |
| Cafeteria | 250 LUX |
| Gymnasium | 250 LUX |
| Library Stacks | 250 LUX |
| Washrooms | 250 LUX |
| Corridors | 250 LUX |
| Mechanical Rooms | 250 LUX |
| Storage Areas | 100 LUX |

* Based on the report "Lighting for Education," Ontario Ministry of Education, 1981

Avoid placement of chalkboards and desks in direct sunlight.

The direction of lighting, be it natural or artificial has a large bearing on how objects are perceived.

Remember also that the needs of children may differ from those of adults - for example the working plane for children in younger classes may well be the floor, therefore ensure adequate lighting is provided at this level.

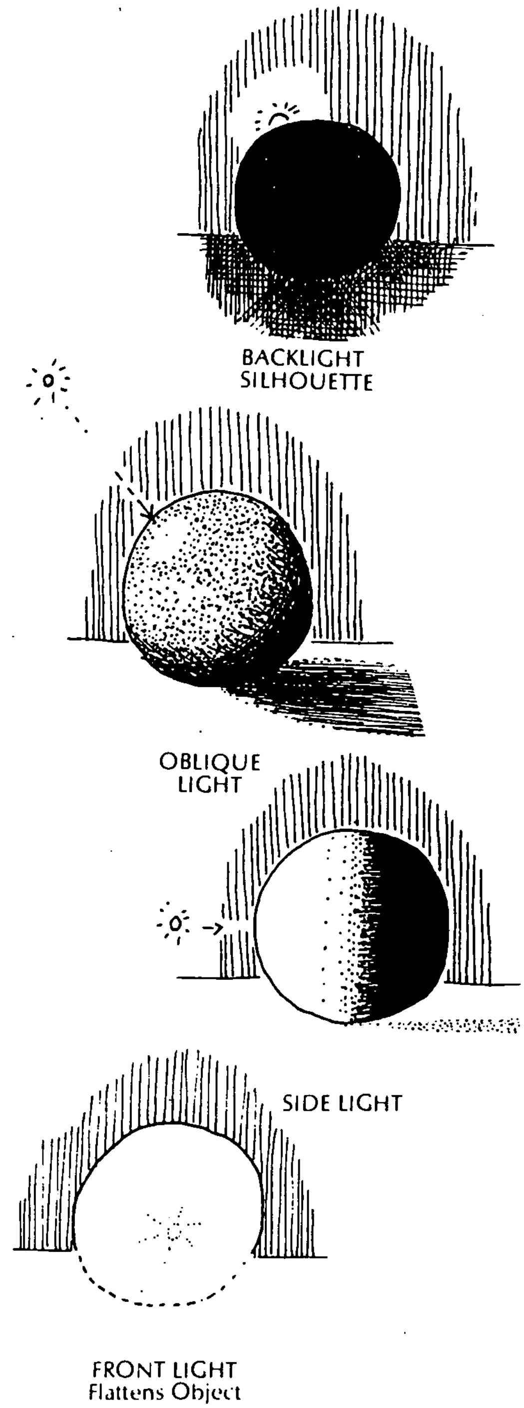
### 5.2.14. Adaptability

Where the school is in a growth phase and rooms need to be changed or adapted to suit various functions, appropriate materials should be chosen. For example, walls covered with pinboard material (floor to ceiling) adapt to a wide variety of functions.

### 5.2.15. Materials appropriate to environment

Material selection varies with the intensity of use of a facility. For example, areas of high student use (especially wet areas) require materials that are hard-wearing, whereas areas, such as reception and staff areas, may be designed using more aesthetically pleasing materials.

When preparing briefs for design consultants, include a policy regarding finishes and the likelihood of vandalism. This policy will assist the design consultants in choosing from the wide range of available finishes. For example, tiles need not be the only vandal-resistant finish available for wet areas. High-quality epoxy finishes are often more suitable for such areas.




PERCEPTION OF SHAPE
Modelling effect of light
The effects vary with direction, intensity and colour of the light source.

## 5.3. Building Services and Systems

This section will deal with the service systems essential to schools:

- electrical systems, light and power (5.3.1)
- plumbing systems. water supply and drainage (5.3.2)
- emergency lighting and warning systems (5.3.3)
- lifts and hoists (5.3.4)
- mechanical services, ventilation and air-conditioning, exhaust systems (5.3.5)
- data transfer systems (5.3.6)
- security systems (5.3.7)

How services are to be incorporated into the building, added to as the building requirements change, serviced and repaired and eventually replaced are important parts of the design philosophy developed by the planning team. The following points should be addressed and documented:

- pattern of distribution for services (e.g. are they to be installed in a formal pattern, perhaps as a grid or are they to be installed only as required extending the services when necessary).
- degree of monitoring of services (will school require automatic recording of operation of equipment for evaluation of maintenance effectiveness)
- remote control of services (will school require remote control of sewerage pumping or water supply systems?)
- provision for maintenance of services (e.g. in ducts or exposed)
- provision for expansion of buildings
- provision for enhancing or expanding services

### 5.3.1. Electrical systems - power and light

In the majority of cases power will be supplied from the national grid via the various supply authorities cable systems. For additional information refer to 2.2.3 and 3.8.3.

#### Main power supply

In suburban and rural areas power cables are usually aerial. In inner suburbs and the larger cities the supply cables are often laid underground.

When choosing a site for a school, advise the local supply authority, who will then request an estimate of maximum demand power load to ensure that there will be adequate supply. An electrical engineer could supply this information provided adequate information as tompotential enroment is available from the school. The authority may require a pole mounted substation. In this event, a small area of land is usually required to be leased to the supply authority.

From this location a number of conduits for cables would be installed to connect the substation with the main power distribution board for the school. Alternatively aerial cables could bring the power to the building. Provision should be made for several additional cables in underground conduits.

The main power board should be readily accessible by road to enable loading and replacing the large switch gear. Direct access is also required for the meter readers and more importantly for the fire brigade in the event of an emergency.

#### Internal power distribution

Power is usually distributed via sub-mains cables to sub-boards from which cables run to the outlets in the various rooms. Several outlets are usually connected to a circuit with limitations on the number of outlets per circuit. These limits must not be exceeded as fire risks result from overloading. Each circuit must be protected by a fuse or circuit breaker. For maintenance purposes, outlets should be identified to show the circuit they are connected to.

Adequate provision should be made for additional electrical cables or for easy replacement of existing cables. Where possible, they should be located in ducts or cable trays. Vertical cable trays are better than horizontal trays as they minimise the impact of vermin building nests in the warm environment.

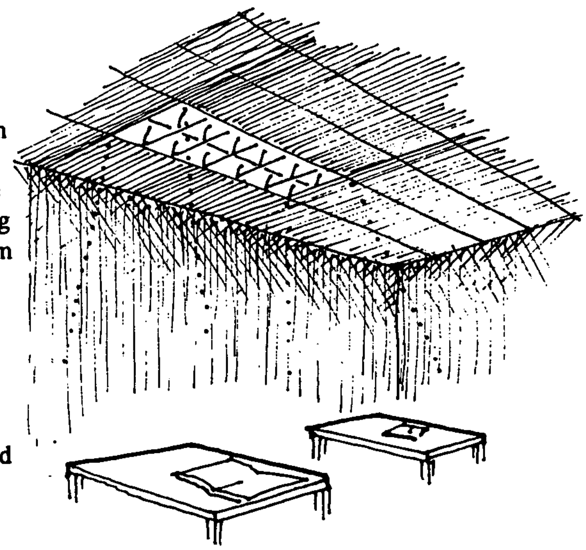
**Electrical systems - light**

The aim of any lighting system should be to maximise light output for the lowest possible power input. The ideal educational environment would have general lighting on the desk or workbench and on the instructor, with separate spot lighting (can be low wattage equipment conserving power – but expensive to install) on the instructor and instructional aids. But given the variety of uses to which many classrooms are put, this degree of lighting is only feasible in dedicated lecture spaces.

A brightly lit room is not necessarily more effective than one which appears less bright. Low-brightness fittings, often involving a low level of light on the ceiling and more light at the desk level, can be highly effective. Properly adjusted and located, this form of lighting is ideal although more expensive initially. Some savings result from lower cleaning costs, and there are higher levels of light for longer periods.

Power savings can be effected by the careful arrangement of switching patterns to minimise usage. For example it may not be necessary to switch on all the lights in a room if sufficient natural lighting is available to one part of the room. Multiple and staggered time switches should be considered.

Lights should operate on a master switch and/or a time clock to ensure than all lights are turned off at the end of a day. These devices allow particular zones to remain lit as required, e.g. for after school activities.



LOW BRIGHTNESS LIGHT FITTINGS FOCUS LIGHT WHERE IT IS NEEDED

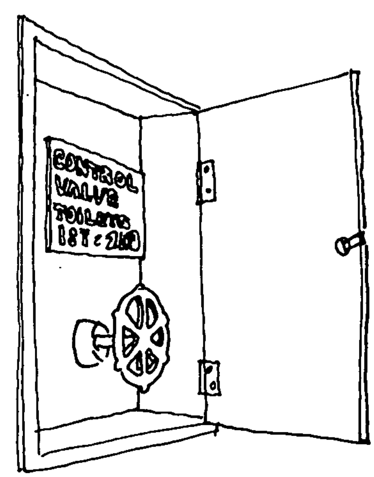
The planning committee should give lighting systems consideration, the decisions to be incorporated in the design brief.

### 5.3.2. Plumbing and drainage systems

Plumbing and drainage pertain to the water supply and to the disposal of fluids and gases. Both are usually handled by the same group of tradespersons.

**Water supply**

To ensure adequate water supply throughout the school and to cope with expansion, mains of sufficient size should be installed. An adequate number of control points fitted with valves should be provided. They should be clearly labelled, specifying the areas each part controls. Labelling is crucial for maintenance and for emergency situations.



LOCATE VALVES CONVENIENTLY & CLEARLY IDENTIFY THEM

Main water supply lines should be identified by plaques or signs particularly where there is danger of damage by heavy vehicles or machinery when undertaking further construction.

Water systems for fire-fighting are usually separate from the domestic water supply system. Fire systems should not be modified without consent of the authorities and should not be used for domestic purposes.

**Plumbing systems - sanitary drainage**

Sanitary drainage is distinct from stormwater drainage. The systems must not be combined. Sanitary drainage must flow to the town sewer or to an on-site sewage treatment system. Any stormwater which accidentally flows into the system disturbs the balance of necessary components of sewage for effective treatment. This applies to both town systems as well as to on-site systems.

All parts of the system must be readily accessible to enable the clearing of blockages. Toilets are best designed with ducts behind the toilet pans to permit access to the back of the fitting (where the majority of blockages occur).

The health and water and sewerage authorities have regulations that regulate the installation of sewerage systems. These deal with size and lengths of pipes, installation of venting systems, traps for foul air etc. For this reason only licensed tradespeople should be permitted to maintain and modify these systems.

**Stormwater drainage**

Stormwater drainage pertains to the handling and disposal of water from the building and site. Here, the primary focus is on drainage from the building - stormwater drainage from the site itself is dealt with in chapter 2.

The system should be designed to cope with balls and lunch wraps, which tend to clog roof outlets and lead to roof overflows. Include "clear-outs" in the downpipes - the vertical pipes connecting eaves gutters to the stormwater drains on the ground.

One effective solution is to discharge the downpipes over a grate, with a gap between the bottom of the downpipe and the grate. This leads to some splashing but is much easier to maintain than other systems. Another method is to avoid roof gutters altogether. Ground disposal is more expensive to install, but the saving on maintenance may well make the investment worthwhile.

### 5.3.3. Lifts (personnel and equipment)

Some forms of mechanical lifting may be required for schools catering for students or staff with disabilities. It may take the form of a lift or a platform which is attached to a stair and rises to the next level, using the space above the stair.

As these are rather specialised facilities, further information should be obtained from the manufacturers of such installations.

Electric or hydraulic lift systems may also be required for moving goods to upper storeys of multi-level schools.

### 5.3.4. Mechanical services

The kinds of mechanical services found in school buildings include:

- air-conditioning
- supply and exhaust ventilation
- dust extraction

**Air-conditioning**

Air conditioning systems can take a variety of forms including:

- reverse-cycle systems which provide heating and cooling as required
- ducted systems where cooled air is circulated to the spaces by means of ducts
- induction unit system where cooled water is piped through coils over which air is forced into localised areas
- self-contained window or wall units
- split systems where a compressor is located remote from the air distribution system - is effective where noise is a consideration

Generally, cooling is carried out using compressor systems or cooling towers. Cooling towers operate using a spray or shower of recycled water over coolant pipes, and require regular testing and maintenance to ensure that deadly micro-organisms such as legionella bacteria do not build up to dangerous levels in the recycled water.

*Evaporative Cooling*

Another form of cooling air is evaporative cooling. It is suitable only in relatively dry environments such as the western slopes of NSW and Queensland. The system operates by passing air across a screen over which water is sprayed or dripped. As the warm air moves through the screen it evaporates the water. The latent heat of vaporisation is absorbed and the air is cooled, as a result. As well as being cooler, the air contains more moisture. In a humid environment, such as the east coast of Australia, this system is not suitable as it makes the air uncomfortably humid.

**Supply and exhaust ventilation**

In schools where rooms are remote from external walls and where it is not possible to provide ventilation via roof lights, forced ventilation, using fans and ducts, is required. The amount of ventilation is usually measured in air changes per hour and are specified in building codes if not in the conditions of building approval.

All ducted systems require maintenance - ducts are notorious for build-up of dust and dust is a fire hazard. Access panels need to be provided and maintenance schedules prepared to ensure that cleaning is carried out.

**Dust extraction**

Dust from woodworking rooms needs to be controlled as it is unhealthy and can have a high explosive potential.

Dust extractors should be installed in technology rooms where dust producing processes occur. Ensure that switch boards are sealed from dust. Also, ensure that methods of dust disposal do not result in shifting the problem somewhere else.

### 5.3.5. Data transfer systems

When installing electrical systems, it is important to be aware of the potential electromagnetic interference on computer screens and data transfer systems. This interference is best controlled by providing adequate shielding and/or isolation from other electrical systems and telephone cables.

See Chapter 7 Technology in Educational Buildings for a more comprehensive discussion of the issues involved in installing electrical systems for technology purposes.

### 5.3.6. Security and emergency lighting and warning systems

Special attention in school design should be paid to regulations to ensure a safe environment. As the amount of expensive furniture and equipment in schools has increased dramatically in recent years, far greater attention must be paid to security and warning systems within schools. Various systems are commonplace in schools, including:

- fire detection and warning
- emergency lighting
- intrusion alerts
- malfunction of critical equipment alerts

*Fire detection and warning*

Fire detection devices include smoke and/or heat detectors located in critical areas. They should be connected to an alarm panel where staff are likely to be while the building is occupied. After hours they should be capable of being diverted to a caretaker's residence. It is also possible to have an automatic phone dialler system installed. In emergencies, these systems automatically dial a series of numbers until the call is answered.

Regular testing of these systems is important to ensure functionality. Both the detectors as well as the system itself need to be tested. If detectors are fitted with batteries, they should be checked as part of a cycle of regular maintenance.

*Emergency lighting*

Emergency lighting is usually installed in escape routes to show the way to exits and to illuminate them. The Building Code specifies where and when they are required.

The lights are powered either by a specially protected wiring and central battery system or by the local power circuit, with individual batteries and recharging units installed in each light. The latter is more common.

Each light is fitted with a small LED (light emitting diode) to indicate that the unit is functioning correctly. The light changes if there is a malfunction.

*Intrusion alerts*

There are a number of ways to detect unauthorised entry, including:

- movement sensors
- heat sensors
- video display
- video display with recording when movement is detected
- glass break sensors
- door sensors

Professional advice should be sought to establish an easy routine to locking the building and arming surveillance mechanisms. Alarm systems can be "armed" (switched on) by key, by cipher pad, by magnetic card, or by remote control.

Alarms can be audible or inaudible at the point of entry. The signal may be remote, such as at a caretaker's cottage by means of the phone lines. An automatic dialler may be activated to ring the home or homes of senior personnel, a security firm or the police.

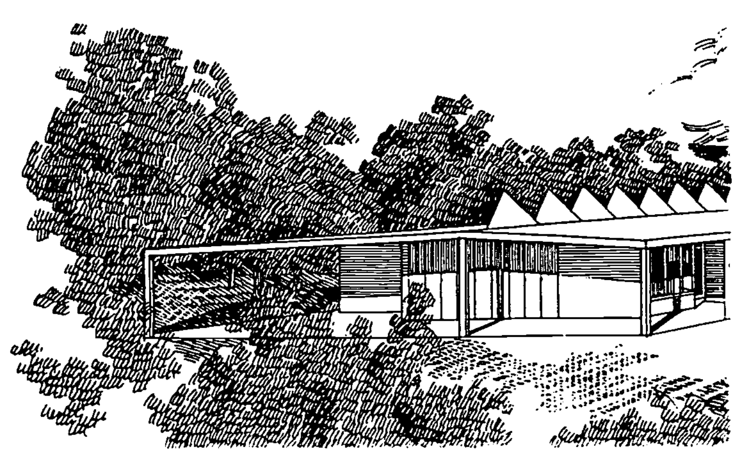
The planning team, particularly the users, should consider the degree of need for security/surveillance and advise the designers accordingly.

*Malfunction alarms*

Alarm systems may be needed for:

- crucial air-conditioning systems
- sewerage pumping systems

If critical equipment fails, leading to damage of products or services if the malfunction persists, then sensors should be installed to provide alarm signals, which work more or less as in intrusion alerts (described above). Plan to have the signals located in areas where staff can monitor them.



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