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BUILDING MATERIALS RESEARCH AND TESTING

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Reprinted from *NEW ZEALAND JOURNAL OF TECHNOLOGY*, VOL.2, No.4 (1986).

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Building materials research and testing

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Abstract The activities of the Building Research Association of New Zealand in building materials research and testing are reviewed. Past, present, and intended research projects in the areas of heat and moisture transfer, fire resistance, and durability are discussed, and the Association's materials testing facilities are described.

Keywords Advisory services; durability; fire resistance; building materials; construction; research; fire tests; test procedures; testing; physical properties; thermal transfer properties; water vapour permeability; energy.

INTRODUCTION

The Building Research Association of New Zealand is an industry-backed, independent research and testing organisation set up in 1970 to acquire, apply, and distribute knowledge about building. This is achieved in a number of ways: direct on-site advice in the field, assessment of new building materials and products, literature searches on both New Zealand and overseas databases, and testing and applied research, the latter either in house or on an external, contract basis.

The Association's studies of the properties of building materials can be divided into three general areas: durability, fire resistance, and heat and moisture transfer. Although there is a general policy of not carrying out repetitive-type testing — which is better given to commercial laboratories — where the cost of setting up a private testing facility would be prohibitive and there is a clear obligation on the Association's part to provide test facilities, this is done. The diversity of materials and components means that a wide range of facilities has had to be developed to evaluate them.

BUILDING PHYSICS

A large proportion of the work of the Association's building physicists is directed at the measurement, modelling, and predicting of moisture and/or heat transfer through building materials or assembled components. The background to this stems from the realisation that future energy supplies are regarded as a critically short resource, both in New Zealand and overseas, coupled with the conclusion that there is scope for substantial reduction in the operational energy requirements of buildings (Trethowen 1980). As well as its influence on heat transfer, understanding the movement of moisture is important for the prevention of problems caused by condensation and mould growth.

Starting in 1970, a considerable amount of the initial effort in this area went into obtaining climatic data for a number of areas of the country for use in modelling, as it was necessary to define the New Zealand climate before its effects on heat and moisture transfer could be assessed. A computer file of climatic data over a 5 year period was built up (Leslie & Trethowen 1977). In parallel with this a guarded hot box was built in the laboratory. This was (and still is) used to measure the thermal resistance, commonly known as the R-value, of wall, floor, and ceiling elements (ASTM 1980).

A further step in laboratory-based work was the construction of two pairs of controlled climate chambers. These are walk-in size and are paired horizontally or vertically to allow the insertion of either wall, or roof, or floor panels. Each box of each pair can be dynamically controlled to its own selected sequence of temperature and humidity. 'Normal' interior conditions and natural climate exposures are simulated (Trethowen 1980). These boxes are used to test and/or demonstrate adequate methods of moisture control within structures and to investigate the effects of moisture movement on insulation systems, and can also be used to investigate the effects of overseas climates on materials or assemblies which are intended for export.

Field studies have provided additional information. Surveys have been carried out on building energy use, water usage in buildings, air leakage and ventilation, the level of insulation performance achieved in domestic insulation (Isaacs & Trethowen 1985), and subfloor moisture evaporation. Lack of basic knowledge has led to more theoretical studies of moisture transfer (e.g., Cunningham 1984).

Routine commercial testing carried out includes the determination of thermal resistance described above (and thermal conductance can be derived from this). On-site determination of thermal resistance is possible. Vapour diffusion (ASTM 1966) can be measured on small samples in the laboratory. A two-pressure relative humidity generator has been built for the calibration of relative humidity measurement devices.

A major problem in the application of research or test results can lie in the fact that materials or components tested in isolation may behave quite differently in the real world when they are installed into a final assembly. In analysing experimental results the final system design and any microclimatic effects must be kept in mind. This phenomenon is not just confined to heat and moisture transfer.

Work planned (BRANZ 1986a) includes publication of a selection of climate data to assist the information needs of people working in the areas of air conditioning, weather penetration, and materials durability. Currently no single collated document exists. Diffusion of moisture in timber above fibre saturation, computer modelling of heat and moisture flow in skillion roofs, and heat flow in concrete slab-on-ground floors are also to be investigated. In the next few years it is hoped that new design aids, both simple and comprehensive, will become available for assessing space heating requirements and also for designing buildings that will not accumulate moisture. For the moisture failures that do occur there should be diagnostic aids for pinpointing causes, and advising remedial treatments. Increasing assistance should be given to designers on ways to keep the weather out. The main emphasis should be on problem avoidance. An evaluation of material properties as a function of age would be of great value both in building physics as well as durability and fire behaviour.

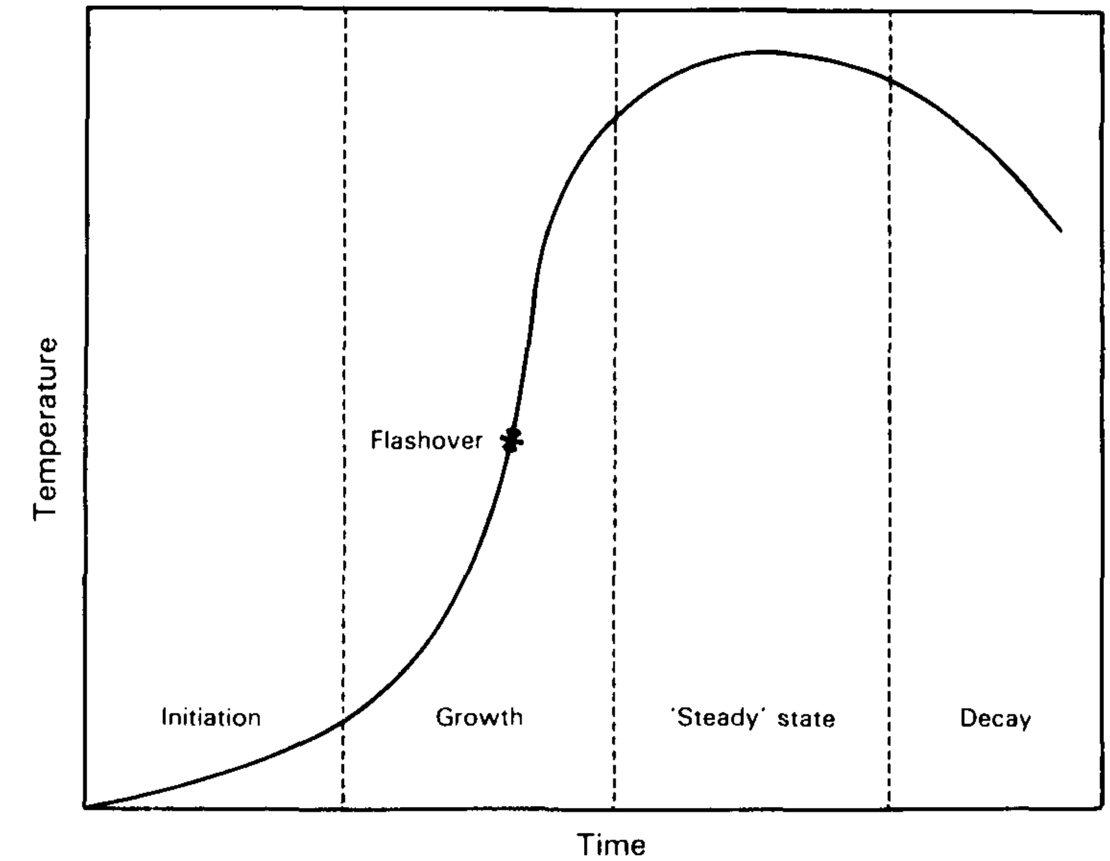

Fig. 1 Relationship between temperature and time, and the stages of a typical uncontrolled fire in a compartment (from Trotter 1985).

FIRE

Fires range in size and type, the most useful way to grade them being in terms of increasing severity of radiated heat. Fire test methods have been developed at arbitrary points along the range of possible severity, each attempting to grade performance at a selected set of circumstances — a cross section at that particular point of severity (Trotter 1985). An idealised graph of temperature at the scene of a fire (taken from Trotter's paper) is shown in Fig. 1. The following four cases are recognised:

Initiation — this could include smouldering

Growth — where the fire finds fresh fuel to spread to (also known as the developing fire);

Steady-state — all available sources of fuel are burning, and the rate of heat release is governed by oxygen supply and surface geometry;

Decay — running out of fuel; cooling begins.

Testing of the fire properties of materials has traditionally been confined to the first three phases. Tests commonly used by the Association have been summarised (BRANZ 1977).

Tests aimed at mimicking the initiation phase of a fire require the application of a small naked flame to the material under test. Examples include AS 1530 Part 2 (SAA 1973), or the Underwriters Laboratory test for plastics flammability (UL 1973). These test results have little relevance, however, to the performance of materials in a developing or steady-state fire.

The next stage — fire growth — is represented by tests such as the Early Fire Hazard test AS 1530 Part 3 (SAA 1982). In this test the samples of material are subjected to radiant heat from a red-hot refractory panel. The distance between a vertically mounted sample (600 mm × 450 mm) and heat source is progressively decreased in such a way as to simulate the radiation received at a fixed distance from a fire which is getting progressively larger and hotter. Results are expressed as indices to four parameters: ignitability, spread of flame, heat evolved, and smoke developed. The higher the index, the greater the hazard. The Early Fire Hazard test is used to assess the suitability of materials for public entrances, exits, lobbies and other places of assembly as required in NZS 1900 Chapter 5 (SANZ 1984).

The third stage — steady state — is represented by ISO 834 (ISO 1975). Composite items of construction such as walls, floors and lift doors are placed into a 4 m × 3 m frame, which in turn is placed into the fire resistance furnace. The test face is exposed to heat from diesel-fired burners.

The furnace temperature is driven according to a defined time/temperature curve. After one hour the temperature is approximately 900°C; and after four hours, approximately 1120°C. Collapse of the specimen, flaming on the unexposed surface, the formation of fissures, or a temperature rise of the unexposed face of more than 140°C above ambient constitutes failure. The time from the start of testing to failure gives rise to the ½, 1, 2, etc. hour ratings for building elements (SANZ 1984). Tests can be carried out on structurally loaded floors and walls as well. No fire resistance tests for roofing are carried out, as there is as yet no agreed method of test. A smaller fire resistance furnace (2.2 m × 1 m) is available at the Association for prototype testing.

Reproducibility is often a problem with fire testing. For example, the reproducibility of smoke index measured by the Early Fire Hazard test (SAA 1982) has been extensively investigated (Trotter & Trotter 1984). Reproducibility of the radiant panel heat source is also under scrutiny. One criticism of the fire resistance furnace test method is the statistical significance of a sample of one; since this test may cost in the vicinity of $5-7,000 for each specimen tested replicates are not called for by the standard and are uncommon, to say the least. There are additional problems in interpretation of the test results — the Association is often called upon to give opinions in regard to the effect of substitution of components (e.g., a door lockset) or scaling-up of size for a real-life situation.

Testing for industry clients both from New Zealand and overseas comprises a large part of the workload, since there are few other early fire hazard rigs and no other fire resistance furnaces in this country. A limited amount of research is carried out: past projects have included a computer-based fire spread analysis of buildings, ignitability of frozen meat carcasses, the fire resistance of load-bearing timber walls and the assessment of heat output from solid fuel stoves on the surrounding building fabric, as well as improving the understanding of test conditions in both the early fire hazard and furnace tests. Proposed work (BRANZ 1986a) includes guidance on design and testing of fire doors, the effects of New Zealand aggregates on the fire resistance properties of concrete, various aspects of the fire performance of light timber frame walls, and the durability of metal flues used in conjunction with stoves and fireplaces.

Looking towards future desiderata in the area of fire research, with the present size of the Association's establishment, it is difficult to see beyond BRANZ following the lead of workers in the UK or USA, and adapting the results for New Zealand conditions. The establishment of some fire engineering consultancies would help to reduce the advisory load on the Association. Present support of building standards by technical input on fire matters will continue.

DURABILITY

Durability is usually interpreted as meaning resistance to natural weathering, as this is commonly the information sought. Occasionally the resistance of materials to other effects — freezing works environments, for example — may be sought (e.g., Sharman 1985). Many of the specialist materials used in New Zealand are manufactured and have some performance history of use in Northern Europe, the USA, or Japan. When transferred to New Zealand with its lower latitude, clearer skies, high humidity levels, and sea-salt aerosol-laden atmosphere their durability may be radically altered (Duncan 1985). Examples of two materials that do not perform as well in this country as they did in their country of origin are so-called weathering steel, which forms a tightly coherent layer of corrosion product in sulphur-containing industrial atmospheres but not in marine ones, and PVC plastisol-coated steel which succumbs to the UV levels associated with our lower latitude and clear skies (Duncan 1985).

The most certain method of ascertaining the weather resistance of a building material is to place it outside and observe its performance over time. Obviously this is of little practical use in predicting likely performance as it takes far too long, so accelerated methods are used. The choice of method depends on the material; caution must be used so that the method selected does not activate a breakdown mechanism that would not occur in natural weathering. The techniques available range from off-the-shelf machines — xenon arc weatherometers (Davis & Sims 1983) or salt spray cabinets (ASTM 1973) — to detailed considerations of likely breakdown mechanisms and the corresponding tailoring of test methods for these (e.g., Jansen & Whitney 1983, Sharman & Vautier 1986). The use of accelerated aging methods is nearly always reinforced, with samples being exposed to natural weathering, with the naturally weathered samples being examined at regular intervals for signs of change, and these correlated to both unexposed samples and to accelerated test results. Methods of assessment range from simple microscopic examination to testing of mechanical properties.

Accelerated test results must be interpreted with care. Usually no statement can be made as to the likely life of a material in years as this is influenced by its specific exposure aspect on a particular building. The information accelerated test results can provide is the types of breakdown mechanisms which are likely (with experience inappropriate results can be recognised), and materials having very similar compositions can be ranked. For materials on which a good deal of information has been acquired from both accelerated aging and natural weathering, some estimates of their life to first maintenance and total life have been made (Whitney & Cordner 1984).

Prediction of the durability of building materials also depends on detailed knowledge of the atmospheric conditions to which these materials will be exposed. Only recently have zones of corrosion risk been suggested for steel exposed in New Zealand, and this was inferred initially from the sodium content of sweet vernal grass (Duncan & Whitney 1982). This paper notes that while industrial pollution can be virtually ignored in this country there is a high level of sea-salt carried inland on the prevailing winds. This, coupled with the relatively high relative humidity of the New Zealand atmosphere implies enhanced corrosion rates for steel. More recently the corrosion risk zones suggested have been shown to be sensible on the basis of two surveys carried out in the Manawatu and Southland (Ballance & Duncan 1986). The general impact of the climate has been much less well-quantified for plastics and paint finishes. Based on results obtained with unstabilised PVC monitors exposed at Wellington (Martin pers. comm. 1977) the ultra-violet levels appear similar to those in southeastern Australia, but the high relative humidity levels may imply more rapid degradation of some polymerics (Duncan 1985).

As well as the ongoing characterisation of the New Zealand environment and atmospheric corrosion studies, past research has included the performance of coatings and protective treatments on galvanised steel and concrete blockwork, priming of timber, the corrosion of metal fasteners in untreated and preservative-treated timber (these particular projects were carried out on a contract basis by Victoria University), performance of floors in freezing works, and the durability of fibre-reinforced cement sheet. Planned research (BRANZ 1986a) includes structural glazing, the mechanical properties of reconstituted woodboards, adhesives, polymer concretes, durability of building plastics, and rehabilitative/maintenance coatings on anodised aluminium and galvanised steel. Routine commercial testing which is available includes natural weathering (SAA 1975, ASTM 1977a), artificial weathering (ASTM 1977b), and salt spray cabinet exposure (ASTM 1973), as well as numerous abrasion, impact, and other mechanical and physical tests on materials.

Looking toward desired future developments for materials durability research there are several areas where progress is desirable. The use of SEM overseas has pointed the way to early identification of the weathering of plastics (e.g., Yamasaki 1982). A BRANZ study carried out in England (Duncan 1982) has shown the value of ESCA (electron spectroscopy for chemical analysis) in weathering studies; the establishment of this technique in New Zealand is desirable. Although there has been some progress with the development of non-destructive testing, developments in the medical field suggest that there are some elegant techniques available which could be applied to materials testing. Although characterisation of the New Zealand climate is underway, any impetus that could be given to this would be useful. Finally, education of manufacturers and designers in the likely performance of materials in the New Zealand climate is seen as desirable.

CONCLUDING COMMENTS

The purpose of this paper has been to give a brief overview of the Association's activities in the field of building materials. More detailed descriptions of projects are given in the Programme of Work, which is published annually (e.g., BRANZ 1986a) and reviews of progress in the Annual Report (e.g., BRANZ 1986b). Beyond this, discussion of individual requirements is the usual method of determining evaluation methods for test clients. Obviously only those research projects are selected which appear to have a good chance of success, and a defined area of application. Contacts both formal and informal are maintained with other bodies carrying out building-related research in this country to avoid duplication of effort. A survey of all building-related research in New Zealand was published in 1984 (BRANZ 1984).

REFERENCES

American Society for Testing and Materials 1966: Test methods for water vapour diffusion resistance of materials. E 96. Philadelphia.

——— 1973: Salt spray (fog) testing. B 117. Philadelphia.

——— 1977a: Recommended practice for atmospheric environmental exposure testing of nonmetallic materials. G 7. Philadelphia.

——— 1977b: Recommended practice for operating light exposure apparatus (xenon-arc type) with and without water for exposure of nonmetallic materials. G 26. Philadelphia.

——— 1980: Test method for steady-state thermal performance of building assemblies by means of a guarded hot-box. C 236. Philadelphia.

Ballance, J. A.; Duncan, J. R. 1986: Wind-borne transport and deposition of sea-salt aerosol in New Zealand. *New Zealand journal of technology 1* : 239–244.

Building Research Association of New Zealand 1977: Fire and buildings — terminology and tests. *Building information bulletin 198*. Wellington.

——— 1984: Directory of building-related research projects in New Zealand. Judgeford.

——— 1986a: Research programme of work 1986–87. Judgeford.

——— 1986b: Annual report 1986. Judgeford.

Cunningham, M. J. 1984: Further analytical studies of building cavity moisture concentrations. *Building and environment 19(1)* : 21–29. [*BRANZ reprint no. 34.*]

Davis, A.; Sims, D. 1983: Weathering of polymers. London, Applied Science Publishers. p. 69–72.

Duncan, J. R. 1982: Electron spectroscopy of chromated galvanised steel sheet after heating, immersion in water or outdoor weathering. *Surface technology 17* : 265–276. [*BRANZ reprint no. 25.*]

——— 1985: Degradation of building materials in New Zealand atmospheres. P. 3–9 *in:* Conference papers IDEA 85: Investment and design, their effects on your assets. Wellington, 14-15 October. Wellington, Ministry of Works and Development. [*BRANZ reprint no. 41.*]

Duncan, J. R.; Whitney, R. S. 1982: Suggested zones of steel corrosion hazard in New Zealand atmospheres. *IPENZ transactions 9(3)/EMCh* : 65–75. [*BRANZ reprint no. 24.*]

International Standards Organisation 1975: Fire resistance tests — elements of building construction. *ISO 834*. Geneva.

Isaacs, N. P.; Trethowen, H. A. 1985: A survey of house insulation. *Building Research Association of New Zealand research report R46*. Judgeford.

Jansen, M. L.; Whitney, R. S. 1983: Performance testing of wood primers. *Building Research Association of New Zealand research report R38*. Judgeford.

Leslie, S. F.; Trethowen, H. A. 1977: A computer file of the New Zealand climate. *Building Research Association of New Zealand technical paper P14*. Wellington.

Martin, K. J. 1977: Personal communication.

Sharman, W. R. 1985. A review of BRANZ food industry flooring research 1975–85. P. 165–173 *in:* Conference proceedings. Building materials durability in the food industry Lower Hutt, 17–19 June. *Building Research Association of New Zealand technical paper P44*. Judgeford.

Sharman, W. R.; Vautier, B. P. 1986: Accelarated durability testing of autoclaved wood fibre reinforced cement sheet composites. *Durability of building materials* : in press.

Standards Association of Australia 1973, 1982: Methods for fire tests on building materials, components and structures. Part 2 — 1973: Test for flammability of materials. Part 3 — 1982: Test for early fire hazard properties of materials.

——— 1975: Methods of test for paint and related materials. Method 457.1. Resistance to natural weathering. Sydney.

Standards Association of New Zealand 1984: Fire resisting construction and means of egress. NZS 1900 Chapter 5.

Trethowen, H. A. 1980: Controlled climate chambers for building research. *Building Research Association of New Zealand reprint no. 18*. Judgeford.

Trotter, K. 1985: Fire properties of building materials and the early fire hazard test. P. 18–27 *in:* Conference proceedings. Building materials durability in the food industry. Lower Hutt, 17–19 June. *Building Research Association of New Zealand technical paper P44*. Judgeford.

Trotter, K.; Trotter, A. B. 1984: An experimental investigation of the repeatability of smoke indices determined by the early fire hazard test AS 1530 Part 3 — 1976. *Building Research Association of New Zealand research report R41*. Judgeford.

Underwriters Laboratories Incorporated 1973: Standard test for flammability of plastics materials. UL 94. 2nd ed. Illinois.

Whitney, R. S.; Cordner, R. J. 1984: Durability assessments of presssed metal roof tiles. P. 99–110 *in:* Proceedings Third International Conference on the Durability of Building Materials and Components. *Technical Research Centre of Finland VTT symposium 48*. Espoo.

Yamasaki, R. S. 1982: Surface weatherability of glass-fibre-reinforced polyester sheeting. 1. Effect of modification of resin chemical composition. P. 84–87 *in:* Composite technology review, Fall. Philadelphia, American Society for Testing and Materials.

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ISSN 0111–7459