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Legget, R. F.; Hutcheon, N. B.

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BY

R. F. LEGGET AND N. B. HUTCHEON

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R. F. LEGGET AND N. B. HUTCHEON
Director and Assistant Director, Division of Building Research, National Research Council, Ottawa (Canada)

INTRODUCTION

The use of indigenous materials was a natural determinant of early building in North America. The igloos of the Eskimo, still in regular use, are always built of carefully selected wind-compacted snow; the teepee of the Indian, covered with hides or birch bark; and the sod huts of the early settlers on the Great Plains – these are some of the more unusual but still typical examples. The availability of abundant wood in the original forests encouraged the early settlers from Europe to adopt it for purposes of shelter. The well-known 'log-cabin', many examples of which may still be seen in use today in rural areas, was the forerunner of a notable development of an architectural style adapted to timber, culminating in the stately New England style of domestic wood-frame residence, and in the rather austere brick-faced heavy timber mill building for industry.

The ravages of fire in cities built largely of wood, together with the changing economic position of wood in relation to other materials, inevitably led to a swing to masonry buildings, both burned-clay brick and natural stone masonry being widely used throughout North America in the late nineteenth and early twentieth centuries. It was natural that the building forms, materials and details with which the early settlers were familiar, those of Europe, should be reflected in the building of the New World, even though some of these were not well suited to the changed climatic environment with its generally hot summers and extremely cold northern winters.

As the new countries of the United States of America and Canada gradually gained maturity, it was inevitable that there should be a similarly gradual breakaway from a slavish copying of European building traditions. With a few pioneering exceptions, this change did not become generally evident until well into the twentieth century.

Typically North American trends in building design and construction are, therefore, of relatively recent origin in general and very recent indeed when compared with European and Asian building practice. Developments in recent years, and especially since the end of the Second World War, have been taking place at a steadily accelerating pace, however, almost as if the art of building were trying to make up for time that had been lost. Today, building in North America is more dynamic than ever before; its current volume is immense by any standard; experimentation in style is no longer the exception.

To analyse the effect of present trends in requirements and in developments of materials and components upon building design and construction is, therefore, no easy task, so varied are the factors of influence and so inevitably interlocked. Economic and social factors naturally dominate the scene. Public demand is a factor which is difficult to assess, so hard is it to separate true public requirement from the wants which result from mass advertising. Developments in building technology have undoubtedly played their part in recent advances, as has also the availability of new materials. Finally, there is a rather indefinite but singularly significant factor that can only be called architectural fashion. Even though these several factors cannot be entirely separated, they will be separately discussed before a final synthesis that will suggest probable trends for the immediate future.

The dollar sign is still an important determinant in North American building. Capital costs are readily measurable. A number of cost indices are available to show the trend of American building costs [1]. One of the best known, illustrated in Fig. 1, is based on a value for the year 1913 of 100 and combines in a single Building Cost Index the sum of a materials component and a skilled labour component. These components are based on the cost of a fixed amount of basic materials (steel, cement and lumber) and on the skilled labour rates for a fixed number

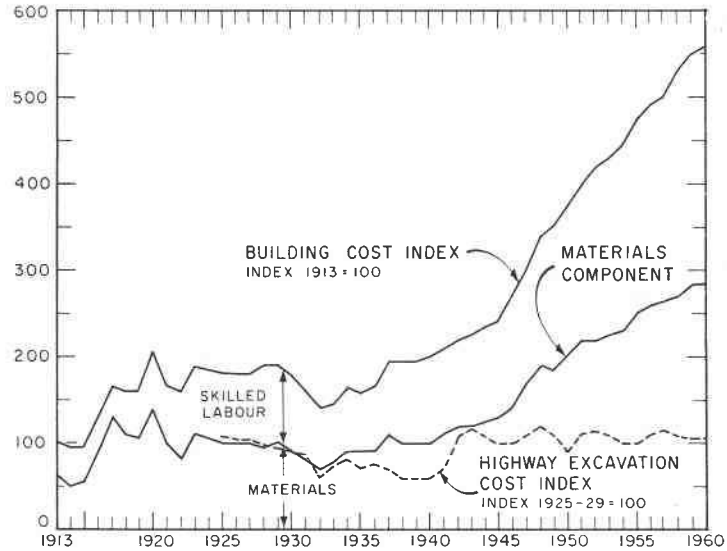

Fig. 1. Cost index of American building showing labour and materials components. Index of highway excavation cost added. (Redrawn from *Engineering News Record* [1, 2].)

of man-hours. The index reflects in a general way the rising costs of the components of construction in terms of dollars and indicates the relatively rapid rise which has occurred since 1945. The ratio of unit costs of materials and labour is shown to have varied but little, at least with reference to the key items selected, despite a general belief that on-site labour costs have risen more rapidly than material costs. There is general concern, however, at the increasing costs of building, partly because of the increasing complexity of buildings as well as rising unit costs, and economies are continually being sought. This has had two direct effects: first, a drastic reduction in the use of hand labour for the elaborate finishing of buildings (such as the hand carving of the Victorian era) and, secondly, the increased use of materials that can be prepared with the aid of factory mechanization for direct use on the job.

Probably the most striking example of this trend is the very wide use of structural steel for building frames instead of reinforced concrete. The contrast that this provides with European practice is a direct reflection of the inversion of the ratio of building material to building labour costs on the two sides of the Atlantic, this fact being an indication of the general increase in the (material) standard of living in North America in the last few decades. The influence of high capital building cost is reflected in various ways, possibly the most extreme being in the design of many large hydro-electric plants of recent years. In many low-head plants where relatively large generating units have to be installed, it is now common practice to dispense completely with the usual 'power-house building' and to provide instead a weatherproof shield covering the top of each unit with arrangements for the complete removal of one unit at a time for servicing into a relatively small maintenance structure.

Concurrently with increasing labour costs an increase has occurred in mechanization in

factories and in certain outside building operations. Possibly the most dramatic example is the unit cost of earth excavation which, at least in the case of highway construction, has varied but little over the years (Fig. 1) due to the development of large-scale earth-moving equipment, and despite the change in the value of the dollar. The index shown for highway excavation in Fig. 1 is the excavation component of the Composite Mile Highway Cost Index of the U.S. Bureau of Public Roads [2].

The high standard of living and the very extensive private ownership of automobiles which it has made possible have combined to provide one of the major social factors affecting North American building, this being the widespread use of private automobiles in place of public transportation systems. Even though there are a few signs that suggest that in a few instances this particular 'pendulum' has reached the limit of its swing, the effect of the private automobile has placed an almost ineradicable mark on building development by not only permitting but encouraging decentralization. Another contributing factor in this development has been the steadily increasing cost of land but the effect of this is hard to estimate whereas the result of the automobile is inescapable.

Factories are now built regularly in the fringe areas around cities instead of in crowded industrial areas, and to an increasing degree in satellite towns. The old central city hotel is being challenged by the motor hotel or motel, many of which are not in urban areas at all but at convenient points on main roads. Vast shopping centres are being erected where there is land available for parking almost irrespective of the location of customers' homes. Consolidated and therefore large schools are rapidly replacing the 'little red school house', private buses and private cars bringing children from a wide area to the central school. The old neighbourhood cinema has been largely displaced not only by television but also by outdoor cinemas where patrons need not go to the trouble of getting out of their cars. The ultimate development of this trend is the existence of drive-in restaurants, drive-in banks, drive-in churches and even (although still, fortunately, in the discussion stage only) a drive-in university.

PUBLIC DEMAND

The buildings just mentioned will, in most cases, be single-storey structures. This definite trend in North American building is probably the result of factors other than financial. It is true that the cost of the necessary structural frame may be reduced to as little as 5 per cent of the total building cost, but the extra costs for heating, maintenance and interior communication, not to mention the restriction which one-storey buildings place upon the optimum use of land, probably offset this saving.

For no building type is the trend more specific at the present time than in the case of housing. Of all houses built in 1960 in the United States and Canada, 60 per cent were single-storey single-family dwellings.

In major cities, somewhat naturally, 'high houses' (to use the expressive European term) are being erected in steadily increasing numbers for low-cost 'public housing' as well as for higher income groups. But considering that almost a century has elapsed since the first real 'apartment block' was erected in New York City – the Stuyvesant block in New York, built in 1869 – the slow progress in the direction of concentrated housing developments is significant. There is no indication of any immediate change in this trend.

There can be little doubt, however, that a powerful influence is the 'prestige' effect of living in a 'modern-looking' residence, even though the origins of such leanings towards prestige are themselves one of the dubious results of advertising. Certainly in the equipment of homes in North America, public demand has been a strong determinant. One garage is today an essential; in many areas, two-car garages are similarly regarded. Some system of automatically controlled heating is today almost universal, with either oil or natural gas as fuel, with electricity emerging as a potential competitor. In warmer areas, air-conditioning is be-

coming to be regarded as an 'essential' (the word is here used in the popular sense). Electrical washers and dryers are but two pieces of electrical equipment that the North American housewife has come to regard as indispensable. And all these home services have developed in general use only since the end of the Second World War. An immediate technical development is proving to be a reassessment of the necessary minimum electrical circuits for residences, so high is the peak load now possible from household electrical equipment. Because of the wide acceptance of interior temperatures of 70° F or more, and corresponding relative humidities for comfortable living, the installation of vapour barriers in association with the necessary wall thermal insulation has become a really essential feature of house design and construction.

Insulation is still not legally required in North American buildings in general despite recent developments in this direction in Europe, since conservation of fuel has never been a matter of national concern. The interest of the home owner in reduced operating costs through fuel economy has led to the construction of dwellings to a high thermal standard, but public, industrial and commercial buildings are generally constructed to a much lower thermal standard for a number of reasons.

The practice of heating all occupied spaces in all buildings for human occupancy to a uniformly high temperature in winter has long been followed and is considered a necessity, the necessary amounts of fuel being expended regardless of the thermal standard of the building. Relatively high air-leakage characteristics with correspondingly low indoor relative humidities have been common in most public buildings.

In recent years the practice of cooling buildings in summer has been growing, somewhat naturally developing first in areas having the more hot and humid summers, and for buildings for commercial enterprises which cater to the public in large numbers. The installation of summer air-conditioning in cinemas and restaurants and to an increasing extent in shops has been common for more than 20 years. Now office buildings and similar establishments are being so treated for the comfort of the worker-occupants. It has been found that when the proportion of office space which is air-conditioned for summer comfort reaches 10 per cent in a city, the economic influence exerted through rentals accelerates the conversion of all other office buildings in that city.

Summer air-conditioning is also being extended to factories to improve working conditions in the interests of easier recruiting of employees, improved employer–employee relationships and increased efficiency. An increasing number of factories is now air-conditioned in the interest of the product or process, and the required conditions may sometimes be in conflict with the optimum conditions for human comfort.

All of these growing requirements and demands for modified and controlled indoor environments, which extend to lighting and acoustical control as well as to air-conditioning, have led in the first instance to greatly increased amounts of mechanical and electrical equipment and services within buildings often reaching 50 per cent of the total building cost. They have at times also had implications directly and indirectly for the design of other parts of the building.

The environmental factor which has potentially the greatest implications for the basic design of the building enclosure is relative humidity, particularly when high indoor relative humidities must be carried under conditions of low outside temperature. The high humidities that are necessary or desirable for some processes require very special designs of the building enclosure. Most buildings heated in winter for human occupancy, apart from dwellings, have not been required to carry other than normally low indoor humidities. The demand for increased indoor relative humidities which is already beginning to develop, particularly in schools, is already creating a need for drastic changes in building designs to eliminate serious difficulties from condensation and accelerated degradation of the building enclosure. The improvement of thermal standards of many buildings is thus linked to the demand for increased relative humidities, as well as to the overall costs for heating or cooling.

It will now be appreciated that it is quite impossible to state whether some of the obvious advances in the techniques of North American building were the result of public demands upon buildings or the precursor of public acceptance of the changes they made possible. Notable among such advances has been the steady abandonment of the old-style bearing-wall type of multi-storey structure in favour of structural frames of steel or reinforced concrete (mainly the former), with outside walls hung from the structure. In recent years, these outside walls have continued to change rapidly, until now their appellation 'curtain walls' is no misnomer but an accurate description of the light, thin, prefabricated panel cladding that is in common use throughout the continent. As the ultimate development of this trend, the extensive use of glass walls, with no solid portions, has become widespread. The development of the modern curtain wall is a development to be welcomed. It is logical; it reduces unnecessary weight; it is capable of sound technical design if the conditions (inside and outside) to which it is to be subjected are fully recognized.

By a strange irony, one of the factors which has encouraged the use of glass alone for curtain wall cladding has been the progress made with modern building regulations. These are now in almost universal use throughout North America. Most of the building codes used by larger cities are admirable documents. But to change them takes time and so the sudden development of the curtain wall is not always adequately reflected in building by-laws. Fire regulations are naturally of paramount importance in all such documents. Windows have long been permitted as exceptions to the requisite fire resistance for outside building walls. It has been argued, successfully, that a wall of glass is nothing more than a large window and so in some cases glass walls have had a temporary advantage over other constructions which when used, have had to conform to the stated requirements for fire endurance. This is a matter that can readily be corrected, and doubtless will be. It is mentioned to emphasize the powerful effect that building regulations can have, and indeed should have, upon advances in building technology.

The use of prefabricated components is making steady but not spectacular progress in North America. The use of structural steel, a prefabricated component *par excellence*, has already been noted. Precast concrete components are coming into wider use but as yet on nothing like as wide a scale as in Europe. Experimentation proceeds apace. In Canada, for example, completely prefabricated bathrooms were used in the construction of a few modern hotels but difficulties in handling did not encourage further progress. It must be added, somewhat naturally without comment, that the influence of the more powerful building trades unions has been successful, especially in the United States, in preventing further advance in the use of many prefabricated groups of components on building jobs. Fortunately, this restriction has not often been applied to the increasingly complex and extensive machinery that is now a part of any modern building, even of the ordinary home. Such equipment must be factory made, assembled and tested; it appears inevitable that this practice will steadily be extended.

Correspondingly, there has been a steady increase in the efficiency of job labour and of construction management. A very high percentage of all concrete used on building jobs, for example, is now delivered at the site ready for use exactly as and when required. It is common practice, especially for crowded city sites, to have an assembly area for structural steel some distance from a job site, steel sections being delivered to the job on a carefully regulated delivery schedule and hoisted directly into place in the structure from the transporting truck. In this way it has been possible to erect the steel for one storey of a large modern skyscraper each working day for a period of some weeks. By such careful scheduling, and through highly developed job management methods, the speed of building construction in North America has been steadily increased so that today it is not unusual for even the largest of buildings to be completed and occupied in periods of less than two calendar years.

NEW BUILDING MATERIALS

Interesting and significant as they are, the newer building materials now available for the North American builder do not appear to have influenced the design and construction of buildings to any major degree. They are used, naturally, in steadily increasing quantities, without leading to any fundamental or unique change but rather as a part of the steadily increasing efficiency of building methods. Precast, and now also frequently prestressed, lightweight reinforced concrete slabs are used for roofs and floors, where ordinary cast-in-place concrete would have been used some years ago. Special combination metallic floors, including ducts and other services, are similarly widely used. Sound-absorbing materials, in aesthetically satisfying finishes, are now generally used for interior finish, especially in ceilings. Ceiling systems which provide for the varied and sometimes conflicting requirements for acoustical control, lighting and air handling and distribution are now being made available. Lighter metals, aluminium in particular, have come into wide use for interior trim and for the frames and sash of windows, and even for insulation in foil form for a somewhat limited range of uses. The large group of new materials generically called the 'plastics' is receiving its widest use as interior finishes and as vapour barriers but is not yet being used extensively for other purposes in modern buildings. In combination with other materials, they are leading to significant developments in the form of 'sandwich constructions', now available in convenient panel forms, following the lead of the aircraft industry. Against the background of this summary review, it will be appreciated that it is difficult to see any major 'break-through' with new building materials. One may rather visualize a steady and progressive adaptation of the many new materials that advances in material technology are providing to the special needs and demands of modern buildings.

ARCHITECTURAL FASHIONS

The vast majority of North American buildings, excluding only the smallest type of individual house, is designed by architects, so that some attention to architectural practice is essential even in such a brief review as this. One most significant factor to be noted immediately is the existence of large firms of American architects practising on a national scale, with branch offices in many major cities. This has the inevitable tendency of introducing a trend towards uniformity in architectural design, with little variation for locality. On the international level the same trend is noticeable, caused undoubtedly by the great improvement in communication through the aid of the visual arts, the wide dissemination of printed matter, photographic illustrations bridging the limitations of language, together with the phenomenal increase in individual travel. Thus it is that the currently popular curtain wall, brightly coloured, rectangularly shaped multi-storey office building has become almost an international architectural style. One is forced to use the word 'fashion' in this connection for it cannot be imagined that, in their search for aesthetic perfection in building design, architects throughout and beyond North America have all individually arrived at exactly the same solution and at exactly the same time. Despite the broad similarity in contemporary design, the situation is dynamic, both with respect to the variety of solutions for the many technical problems and to the search for new architectural forms.

The demands upon modern buildings are such that it does not take long for any conflict between architectural styles and technological requirements to make itself evident. It is now not uncommon in North America for the cost of the mechanical and electrical services in a modern building to amount to at least 40 per cent, and in some cases 50 per cent of the final contract price. Such a situation demands the very best of combined architectural and engineering services, working together from the start of the planning of a building project; this is not always achieved. The architect is the dominant member of the team and no one questions that he should be. But his formal training unfortunately gives him little basis for un-

derstanding, and indeed often little interest in, the technical and economic implications of some of the architectural effects which he is attempting to achieve. This has not in the past been nearly as serious as it is now, because the materials and the ways of putting them together changed only very slowly over the years. Now, the new materials and arrangements of materials which are being offered are stimulating the architect to attempt many innovations for which there is not always corresponding background of experience or skill on the part of those who must execute his designs and make them work. Many examples might be cited from contemporary designs in which some of the architectural features have been committed with little regard for the technical and economic problems created, or of the ways in which they might be solved.

Since the war years there have developed in the United States some large firms of architect-engineers, a development necessitated by the advent of war. Another development, of more dubious value but one understandable in view of the sudden recent upsurge in building technology, is what is known as the 'Package Deal', an arrangement whereby the one firm does the initial planning, preparation of working drawings, and also carries out the construction. A further development, and one with powerful persuasion for prospective building owners, is for the same firm to undertake also the financing of the building, the ultimate development being the leasing of space in the building to the would-be owner, removing even the necessity for capital investment on his part.

Money 'talks' in North America, as elsewhere, and so the inroads of the Package Deal in recent years have been quite remarkable. Despite the apparent advantages of the system, the lack of the independent judgment of the professional architect-engineer is a serious weakness, indeed a fatal flaw, in the system, even assuming first-class technical competence.

A FINAL NOTE

Prophecy is always a dangerous pastime. No 'conclusion' is to be drawn from this review, therefore, but since trends continue, the trends herein so briefly sketched will continue and some prediction as to their immediate future appears to be warranted. It seems certain that the architectural fashion of the use of excessive glass cladding for buildings has passed, or is passing, its peak, and that a return to more solid, but still lightweight curtain walling is inevitable. Demands for interior environment, now that air-conditioning and humidification are so well accepted, cannot become very much more stringent, so that renewed attention to the details of building design in order to meet these demands efficiently and economically is to be expected. This will call for changes in architectural training and even in architectural practice, with a much closer link with engineering than has been the case in recent years.

That such advance in the efficiency of design, to parallel the efficiency already obtainable in building construction, is essential is shown by even a glance at the volume of building that will be necessary in North America in the next few decades. It is estimated that, in the next ten years, the number of schools must be doubled. Rather than belabour this point with an array of alarming statistics that could quite properly be cited, let this one figure stand alone. It is a challenge to architects, to engineers, to builders.

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