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Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/20378570
Technical Paper (National Research Council of Canada. Division of Building Research), 1971-11

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CODES, STANDARDS AND BUILDING RESEARCH

by N. B. Hutcheon

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NATIONAL RESEARCH COUNCIL OF CANADA
DIVISION OF BUILDING RESEARCH

CODES, STANDARDS AND BUILDING RESEARCH

by

N. B. Hutcheon

Technical Paper No. 357
of the
Division of Building Research

Ottawa
November 1971

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INTRODUCTION

Standards in building have been the subject of increasing interest and discussion, both specific and general, over the past few years. Performance codes and standards have been under active discussion in many countries and were a major topic at the recent Congress of the international building research organization CIB (Conseil International du Bâtiment pour la Recherche l'Etude et la Documentation). The use of criteria stated in performance terms has been highly publicized through the OPERATION BREAKTHROUGH program of the Department of Housing and Urban Development in the United States.

In Canada the awareness of the link between standards and building codes, associated with successive five-yearly revisions of the National Building Code (1), has been accentuated in recent months by discussions of the need for uniform provincial building codes. Talk of systems building and the industrialization of building has promoted questions concerning new standards to cover the products required in these developments. Performance standards have been publicized through the Metropolitan Toronto School Board Project SEF (Study of Educational Facilities). The production of factory-built housing in Canada and the rapid growth of the mobile home industry have stimulated new standards activities and led to further discussions about other standards needs of the construction industry.

The Economic Council of Canada became interested in standards as they affect the national economy and sponsored jointly with the Science Council of Canada the publication Standards in Canada by Robert F. Legget (2). The Standards Council of Canada, established within the past year, has begun its work, directing its attention first to international standards. Standards inevitably are thought about in the context of metrication, which has been recognized officially in Canada by the establishment of a Preparatory Commission on Metric Conversion.

Certification and approvals and the evaluation of materials, although not strictly a part of the subject of standards, are nevertheless very closely associated. Certification is concerned with compliance, while approvals and evaluation are more concerned with the lack or inadequacy of codes and standards. Building officials in Canada have had a long-time interest in obtaining assistance from some central agency with their problems of building code approvals.

This has recently been renewed by the special problems posed by factory-made houses and mobile homes coupled with the interest in uniform provincial codes. The special interests in these matters of various agencies both inside and outside governments have been increasingly under discussion and review.

Appreciation of the varied nature and implications of standards is required. Progress is being made through the discussions promoted by the various activities and, in turn, creates a need for a grasp of the broader picture. From the very nature of its work, including the assistance it renders to the Associate Committee on the National Building Code, the Division of Building Research has been involved in a continuing contact with diverse standards activities over more than twenty years. The paper now presented is an attempt to set out some of the considerations about standards, growing out of that experience, that appear to be in need of appraisal and review.

Somewhat naturally, the paper emphasizes those topics arising out of the Division's interest that seem most urgently in need of clarification and does not aim specially for an exhaustive or comprehensive presentation. Part III is, in fact, a description of the Division's involvement in codes and standards, with the thought that it may be useful as background information. The present paper is, in a sense, three papers represented by the three parts, each of which can be considered on its own, but now presented as one because of the strong connection.

PART I: STANDARDS AND BUILDING REGULATIONS

Building codes are large and important instruments in the regulation of building. They depend quite critically on the existence of a great many other codes and standards. Their current status, their requirements and their probable future development, therefore, are of such relevance to the standards picture that they merit detailed discussion.

The regulation of building has always been linked closely to local government. One can imagine that in the early days it was left to the people on the spot to deal with the hazards of structural collapse, fire and disease as best they could, often while under the stress of some recent disaster. Although today provincial governments retain direct control over most safety matters, all provinces allow their municipalities to pass bylaws for the regulation of building in the public interest. There are, therefore, some 4,000 municipalities in Canada permitted to exercise jurisdiction within the limits set by permissive provincial legislation.

All provinces exercise directly the right to legislate for safety in such matters as the distribution and use of electricity, gas and oil, control of fire hazard in certain public buildings, and such specific items as boilers, pressure vessels and elevators. These statutes naturally take precedence over municipal building bylaws when they are more restrictive. Municipalities are also permitted to pass planning and zoning bylaws. These affect building but are more concerned with control over the use of land and the nature of city development. Building bylaws, on the other hand, have normally been limited to matters of safety about buildings themselves in respect of structure, fire and hygiene. There is a growing tendency, however, to allow matters of amenity, including appearance and quality, to creep in.

The Model Code Approach

Building bylaws have evolved largely in the hands of local governments and can differ widely in content and degree of development from one municipality to another. The desirability of greater uniformity was recognized and the first real steps toward this were taken about 35 years ago. The idea of a National Building Code, which could be voluntarily adopted as the basis for all municipal bylaws, was developed when the Government of Canada introduced the first National Housing Act. The first National Building Code was completed in 1941.

The second edition, prepared under an Associate Committee on the National Building Code, appointed by the National Research Council with the assistance of the newly established Division of Building Research, was not completed until 1953. Since then there have been new editions in 1960, 1965 and 1970.

All provinces have commended the National Building Code to their municipalities and have enacted the necessary enabling legislation. A large number of national bodies have indicated their support. Adoptions occurred at an increasing rate over the years, but in some cases were only partial, and not all municipalities saw fit to update their bylaws as each new edition of the National Building Code appeared. One or another of these actions has been taken by more than 80 per cent of all the urban municipalities in Canada. Thus, about 80 per cent of all building in Canada is constructed in accordance with building codes that are wholly or substantially in agreement with one or another of the five editions of the National Building Code.

Although this falls far short of complete uniformity in regulations, it is still a remarkable achievement, keeping in mind that 4,000 separate municipal jurisdictions are involved and that substantial adoption began only after the appearance of the 1953 Code. Many associated matters have had to be improved also, including the preparation or improvement of codes and standards in support of the National Building Code as well as changes on the part of the municipalities. In this connection, building bylaws cannot be made to update themselves when a new referenced standard appears; the reference must always be to a specific document and can be changed only by amendment. Municipalities that have bylaws based on old editions of the National Building Code are, therefore, using also old editions of the referenced standards unless they have amended their bylaw periodically to take account of the latest revisions of standards. Even if the municipality adopts the latest edition of the Code, it may still be referencing a five year old standard, which will be 10 years old by the time of the next Code edition. Yearly revision of all bylaws may be the best answer.

It was formerly the practice of the Associate Committee on the National Building Code to publish revision slips covering individual revisions to the National Building Code at any time. Building officials and other users of the Code were therefore informed of the most up-to-date decisions on Code content, though it was seldom possible to respond to them with frequent bylaw changes. Beginning with the 1970

edition of the Code the accumulated revisions are to be published annually and incorporated in the Code itself when a new edition is published every five years.

Uniform Bylaws and Regulations

The long-standing campaign to promote the National Building Code continues to gain momentum. Several provincial governments have recently taken major steps to promote uniformity of regulations. It is not clear, however, that all provinces will necessarily do the same thing. Uniform regulations for the whole country quite clearly will only be achieved if all provinces agree to adopt the same code, and the National Building Code is the obvious choice. Uniformity of building bylaws is, however, only a part of the whole matter of achieving uniform regulations. Most provinces have, in addition to various safety codes, a number of other acts dealing with one aspect or another of building, and administered by several different departments. There is also the matter of uniform interpretation, administration and enforcement to be considered if real uniformity in practice is to be achieved.

The developments that have taken place in Ontario to date are of particular interest since they envisage a rational, uniform system of regulation based on an Ontario Building Code and an Ontario Fire Code, both of which are to be as nearly identical to the two corresponding national codes as possible. The Committee on Uniform Building Standards for Ontario has recommended in its Report, published in November 1969 (3), that the present acts, regulations and policies and all other conflicting private acts or municipal bylaws, insofar as they deal with building, be repealed or revoked and replaced by the two Codes. Other acts or codes, given by name, or parts of them which deal with relevant matters of safety, are to be assigned for administration to one department, along with the Building and Fire Codes. Thus, all administrative authority having to do with building and construction, hygiene and safety will be held by a single department. The province has already authorized the establishment of two recommended review committees, one on codes and the other on enforcement. The latter will consider relations with municipalities, inspection and the qualification of inspectors, interpretations and approval of new materials or methods of construction or computer programs. The Ontario committee has seen clearly the need to reduce the number of authorities having jurisdiction at the provincial

level as well as to provide for uniformity at the interpretation and enforcement stage, and has made clear and positive recommendations regarding them.

New Needs for Provincial Codes

The shift from municipal to provincial jurisdiction, as envisaged in Ontario, creates new situations and new needs, not only for the Building Code but also for enforcement, limited only by the degree of refinement in practice that is sought. The general nature of these requirements can be predicted from experience in the enforcement of the many provincial safety codes such as those for electricity, oil and gas appliances, elevators and pressure vessels that have long been in effect. They have serious implications for all agencies concerned with standards and standardization on behalf of building.

The qualities of a building, like any manufactured article, are determined by the materials and components built into it as well as by the way in which they are put together. The regulation of safety, therefore, requires that a measure of control be exercised over both materials and construction. As buildings are constructed at the site, inspection to establish that regulations have been complied with must also be carried out there, as far as on-site manufacturing and installation are concerned. The materials, components and equipment delivered to the site may be inspected for compliance at the time of delivery, but in many cases this can be done better and more economically at the source of supply, that is, the factory.

The essential features of a practical system of regulation for building can be identified quite clearly. The regulations must be as clear, complete and unambiguous as possible, not only to the inspecting authority but to everyone else who must follow them. Extensive use must inevitably be made of standards, since this is in large measure what standards are for. There must be sampling and testing of materials and components to determine compliance with the relevant standards. This may be done at the factory, at the warehouse, or at the site. The batch or lot intended for a particular job or as delivered to the site may be identified, proper representative samples taken and tested, and certificates covering the test results provided for examination by the inspector. Alternatively, where mass production is involved and it is appropriate or necessary to be able to give assurance of

compliance of all or any part of the production, there may be sampling, testing, and regular inspection as a basis for certification by an appropriate testing agency acceptable to the inspection authority. Where a large measure of judgement must be applied alone or in addition to evidence provided by test results in determining compliance with a code or standard the authority having jurisdiction may make the judgement, based on advice from others expert in the particular field, thus "approving" the product or practice for use. The certification or approval can be made known by listing or labelling so that all concerned, including the inspectors on site, may know that the products comply.

In these ways the inspector can be provided with evidence of compliance for goods brought to the site. He must, in addition, inspect on-site to make sure that the installation also complies with the Code. There is an obvious need for qualification of inspectors, involving training and examination, and this may be arranged as an essential part of the system of regulation. Since total inspection is impractical, the necessary standard of workmanship may be promoted by the training and licensing of craftsmen, as for the electrical and plumbing trades.

This discussion of the regulation of building safety is somewhat academic as far as current practices in the administration of building bylaws are concerned. The features described are a necessary part of a rational and reasonably adequate system of control, but few municipalities to date have proceeded very far in this direction. There are undoubtedly many reasons for this, but the situation becomes more understandable if one considers the size of the average municipality of 5,000 people with its own municipal council having the power to pass building bylaws and to hire and fire its own building official. The value of building construction averages about $1.6 million per municipality and is supported and carried out partly by people in the municipality for the people of the municipality. This is a distorted picture in one way, however, since only about 10 per cent of the population lives in municipalities of 5,000 or less. A more meaningful figure would be 100,000 population since half the population lives in municipalities this size or larger. The pro-rated level of building construction would be $40 million per year, enough to construct 2,500 dwelling units if entirely used for that purpose. Even this is a relatively small jurisdictional unit, quite capable on occasion of settling disputes by a vote of the municipal council rather than by rigid enforcement of an elaborate code.

Standards for Building Codes

The National Building Code 1970 makes direct reference to standards. Of these, 88 are Canadian Standards Association, 50 are Canadian Government Specifications Board, 32 are American Society for Testing and Materials, 12 are American National Standards Institute, 10 are Underwriters Laboratories, one is U.S. Federal, only one is British Standards Institute, and four are National Fire Protection Association. This is only a small part of the several thousand standards listed in the CGSB Building Standards Index (4). It is difficult to say how many standards should be used in a code and what are the actual limiting factors in the use of more standards in building. It is difficult to avoid the conclusion that doubling the number of standards referenced in the National Building Code for commonly available products would have relatively little influence upon the amount of testing called for as evidence of compliance in the enforcement of municipal codes. It is probable that this is considered unnecessary for the majority of standards referring to materials familiar to all concerned. Certain properties that are critical in respect of structure, fire and hygiene, such as quality of concrete and steel and fire performance, are, however, quite widely examined. In many cases building officials may accept assurances of compliance from others without verification.

The standards in building codes are invariably national standards in the sense that they are suitable for use throughout the country and reflect a reasonable position in respect of any major conflicts of interest among producers, users, and others. Manufacturers will normally choose to make products that meet such standards because for several reasons it will be in their interests to do so. The influence of a standard is not therefore determined directly by the extent to which evidence of compliance may be demanded as a condition of sale. The manufacturer will often be glad to supply goods in all cases that meet the standard in order to avoid complications in some situations.

On the other hand, manufacturers will respond quickly to any new requirement if it is enforced. They will be concerned only if the new requirement affects their competitive position either as individual firms or as an industry. They must always ask that the same requirements be applied to all potential suppliers. Ultimately, competition from the ignorant or the unethical supplier who delivers inferior goods may force the ethical manufacturer out of business or to disregard standards himself, or to seek ways to ensure that all suppliers will be required to meet the same standards.

Undoubtedly a kind of balance has been achieved in each community under the present municipal systems of control between the extent of the regulation actually achieved and the effort put into enforcement. It can be predicted that a shift to a provincial code and a single province-wide jurisdiction will not only create a need for the use of more and better standards, in efforts to make codes more complete, but also for more evidence of compliance. It can also be argued that it will be much easier and less costly under the new system to organize and to make extensive use of certification. This might even be accomplished on a nation-wide basis if most, if not all, provinces adopt the National Building Code.

There are no fundamental difficulties in providing certification of compliance. The standard involved must be properly prepared in measurable terms, leaving little doubt as to what is required. When there is a real demand for certification as a condition of use or of purchase, the manufacturer will provide it at his expense. He must have available the services of testing laboratories which are competent and unbiased so that the certification will be acceptable to the authority having jurisdiction. Standards agencies need have an involvement only at two points: in the preparation of standards which are an adequate basis for certification, and possibly in the establishment of standards for the qualification of testing laboratories and the proper control of their work. Certification must be carried out all across the country, wherever there are factories. There is no fundamental reason why a number of testing agencies should not be involved, as long as they are competent. The most difficult problem in the enforcement of building codes is, however, the matter of approvals. It merits special consideration.

The Approval of Building Products and Construction

Approval in its broadest sense involves consideration and confirmation for the guidance of others that in the opinion of the approving authority the product involved will meet a stated or implied set of conditions. The safety official approves materials and methods, indicating that their use will conform to the legislation from which he draws his authority. This is the meaning with which the word is used in the National Building Code, i.e. "approval by the authority having jurisdiction".

The ideal regulatory system is one in which all requirements are set out so clearly and concisely in terms of standards and test

methods that all that is necessary in any situation is to identify the applicable standard and test to determine compliance. Thus the testing agency's certification becomes all that is necessary to indicate to all who follow, and without further reference to the authority having jurisdiction, that the product is acceptable for purposes of the regulation. The act of certification should never be considered as approval.

The reality is, however, that neither codes nor standards are perfect, so that many situations may not be clearly covered or may not have been anticipated at all when the documents were prepared. It is this inadequacy of law and legislation generally which keeps the legal profession fully occupied. It arises because knowledge at the time was inadequate or because the law, including the codes or standards involved, did not exploit the knowledge available, or because it was impossible to predict all the situations that develop.

It has been customary in writing building bylaws to give to the building official the power to interpret and to pass judgement on all situations affecting safety that are not already clearly covered in the building code. Such situations may be introduced by new building forms, new uses for buildings, new materials or new combinations of known materials. The building official is thus faced with a responsibility which compels him to deal with complex and difficult matters as best he can. He must "approve" those things which he is prepared to accept, while rejecting others. He must either be conservative, rejecting those things which are not, in his opinion, well supported by evidence of safety, or accept new things freely, allowing future experience to provide statistical evidence of the hazard they present. In either case he will be criticised for hindering new development or for failing to protect the public.

Regardless of any debate over the legality of delegating responsibility for approval, it is quite evident that the safety official will often find his own resources inadequate and will welcome assistance. In the regulation of electrical safety, which is a provincial matter, there is an Approvals Council that meets under the auspices of the Canadian Standards Association to "approve" electrical products examined by the CSA Testing Laboratories and subsequently labelled as approved by CSA. It would be logical to assume that the approval is really exercised on behalf of the ten electrical safety officials by the Approvals Council, which has representatives from each province.

The present situation with building bylaws is neither so readily handled nor so well developed, in view of the many municipal jurisdictions. There has been a demand by building officials over the years

for assistance in the evaluation of materials and components, but this was not considered appropriate until the National Building Code itself was well developed. Two large organizations in the United States, the Building Officials' Conference of America (BOCA) and the International Conference of Building Officials (ICBO), that sponsor national model codes provide "approvals" of building materials, components and systems. These are really recommendations to the building officials of the adherent municipalities to approve, since neither organization has any legal status.

The situation in Canada is undergoing a marked change under the pressure of requirements to deal with factory-built houses. As it is clearly not practical for every building official who may have factory-built houses submitted for approval to make an inspection at the factory, there has been a demand for factory certification by a single agency. A request has been made to CSA by the Canadian Building Officials' Association to certify compliance of factory-built houses. A start was made on a new code, but it soon became clear that there should not be two codes and that what is wanted is evidence of compliance with the National Building Code.

The present situation in Canada is complicated by a lack of clarity in defining and understanding what is involved in certification and approval. There cannot properly be certification of compliance with the National Building Code since the NBC leaves many matters to be decided by the "authority having jurisdiction" and thus does not provide a suitable basic document for certification in all aspects of house safety. Approval on behalf of the building officials is required. This is clearly recognized by ICBO in the United States where the approvals aspect of a particular set of plans and specifications covering a factory-built house design is decided by a committee of building officials and the certification aspect is confined to determining compliance of the houses as produced to the approved plans and specifications.

The Canadian Standards Association is preparing a standard covering the inspection of factory-built houses and proposes, with the help of a CSA Advisory Committee which it has established with heavy representation from CBOA, to certify as to compliance with the National Building Code. It is recognized that unusual features not explicitly dealt with in the National Building Code may require special technical consideration. The Associate Committee on the National Building Code has been approached and has agreed to give advice to CSA on such matters, recognizing that assistance to the building officials in dealing with factory-built houses is an urgent requirement. It would have been

quite consistent with current practices if CSA had simply undertaken to certify that the manufacturers' published plans and specifications were followed, leaving the building officials to decide later whether they would approve. This would not have provided the manufacturer, who must pay for certification, with any prior assurance of approval nor have offered the economy and uniformity of evaluation by some central agency. On the other hand, it could have accommodated very well to differences in codes, since the building official could accept the certified plans and specifications in lieu of his own inspection at the time he was faced with a request for approvals in respect of his particular building bylaw.

It is important that the difference between certification and approval be clearly understood and widely recognized. Standards bodies have a special interest in this, since they must be interested in the use as well as the limitations of standards. Certification in general involves the use of a suitable standard, requiring that adequate knowledge has been available and that the standard has been well prepared. Approval becomes necessary when, because of a deficiency in knowledge or in some other aspect of the code or standards-writing process, there are not adequate standards for use or when new materials, components and systems appear and must be appraised.

Conclusion

It is difficult from any over-all consideration of building regulations to identify a firm basis for deciding when new standards are required in support of building codes. Presumably, those who were involved in the preparation of the National Building Code 1970 saw no need to employ more than the 198 standards selected, representing less than 10 per cent of those available. They were, however, mainly concerned with the maintenance of safety and hygiene, which meant that only those standards which were useful for this purpose needed to be considered.

The close attention paid to certain critical structural and fire-safety characteristics suggests that standards are prepared, adopted and enforced in direct response to need and to the importance of the result to be achieved. Voluntary standards may be prepared because users or suppliers have a problem that can be resolved in this way. Safety standards may be written in support of provincial safety legislation.

All of this suggests that the needs for new standards in support of building codes cannot be fully envisaged at any given time but that they are revealed on a continuing basis in the course of preparing, evaluating, revising and enforcing codes, as well as through the experiences of society in the use of buildings. One such general requirement, which can be foreseen, is that for increased detail in regulations to assist in uniform enforcement of provincial building codes. This, in turn, will call for a greater use of standards and certification.

PART II: STANDARDS AND PRODUCT EVALUATION FOR BUILDING DESIGN

Building design is carried out most commonly by professional consultants acting as the owner's agents and accepting responsibility that the building will, as far as possible, meet all the owner's requirements. Although it is convenient to think of the designer as one man, the design function is usually carried out by one or more architects and a number of engineering and other specialists, each making a contribution that will be coordinated in the total design.

The designer must naturally see to it that his building meets the minimum requirements for safety, as set out in building bylaws and other legislation, in addition to the functional requirements his design envisages. He must decide upon and specify many features with which building codes are not concerned, and may even arrange for greater safety than the code requirements provide. In all of this the designer can make extensive use of standards in support of design.

There is widespread criticism, particularly from architects, that present standards do not control all the factors of interest, and that more and better standards are needed. These criticisms merit careful consideration, but they often reflect a lack of appreciation of the nature of standards and of their strong dependence upon the adequacy of knowledge of the subject being treated at the time they are prepared.

Standards in Design

The problems of the designer are not unlike those of the code writer or any purchaser of commodities who must decide what he wants to do and must know and be able to assess the various products and practices he may call up in achieving the desired end result. He must also describe in clear terms what it is he requires of others in the construction of the building, and may as a proper part of his professional responsibilities inspect to ensure that what is required has, in fact, been provided. Standards can be of assistance in all of these matters. Indeed, they are such an intimate part of all transactions involving goods bought and sold on the basis of measurable properties that it is almost impossible to avoid them. Standards are ready-made descriptions that can save a great deal of time in describing what is wanted. They will usually be well known to people in the trade and thus facilitate communication about the goods they describe.

They also call up standard products in regular production that should be readily available at lower cost than non-standard or custom-made or special items.

There is, however, a very important condition which the designer must fulfil. He must decide whether the product called up by the standard he selects will perform as required and provide the level of quality he intends for his design. This is a most serious point which, unfortunately, is often not appreciated. When the designer is the only man who knows what he is trying to do, he must expect to have to make a choice from what is available or to describe, with or without the aid of standards, some non-standard product he requires.

When the particular requirement is a common one, which has been anticipated in the preparation of suitable product standards and suitably identified in the title or scope, the designer may choose to rely upon such identification alone as a basis for selecting the standard. He may also know, through previous use or familiarity with the sponsoring agency or assurance of some other authority, that particular standards will be suitable. In other cases, where such assurance is lacking, an examination of the contents of the standard may be necessary as a basis for choice. This is also the problem of the code writer who must decide that what is specified in the code will, in fact, accomplish what is wanted. There is no way of avoiding this issue, which calls for the exercise of a high level of professional competence, except by delegating authority. This may well be unacceptable unless the designer is also in a position to delegate responsibility as well.

When the available standards are entirely suitable, the determination of compliance with the requirements at the time of delivery or procurement can be based on sampling and testing at that stage. Adoption of the practice of calling for certification could facilitate this even further, promoting examination of total production at the factory.

The designer, when he is unable to find suitable standards, may adopt an approvals approach very similar in principle to that followed by safety officials. That is, he may reserve the right to exercise his own judgement about the products offered and to indicate whether or not he will accept them. This has an awkward feature in contract documents, in that the builder or supplier has no firm basis for estimating the cost of what it is he will be called upon to provide.

It is a common practice in contract specifications to name a particular kind of product, or even a particular manufacturer's product. This practice has many debatable features. It can make for good law in a code or in a contract since it leaves little doubt as to what is being asked for. On the other hand, other suppliers who believe that they have suitable products complain that they are not allowed to compete. At the same time, if the designer has not chosen well, he may not get the best product available. He may not even know at the time of specifying about other possibilities. Thus the specification approach can be highly selective, but may also be highly restrictive, particularly when followed on large jobs or in contract documents or codes that are widely used. The alternative of specifying the final result, that is, the required performance, leaving the selection to be made from among the products or solutions offered, is intellectually appealing and can, in certain cases, be an excellent procedure.

Performance Standards and Specifications

Despite the great favour with which it is regarded, the performance statement, whether used in specifications, standards or codes, may not be the best way or even a good way of calling up what is wanted. Limitations, when they exist, are associated with inability, through lack of knowledge, to set out the performance required in terms that can be measured or the impracticality of carrying out all the tests that may be required to evaluate the performance. In some cases, the statement of requirements may involve a very large number of considerations and may pose a very formidable task of selecting or devising the necessary ways in which these can be measured. The advantages of this approach can be more apparent than real when there are only one or two well-known possible choices. The possibility that a novel, but entirely satisfactory, solution will be rejected unfairly is probably much smaller than is commonly assumed. The cause for rejection will usually be inability to establish the adequacy of the performance or service that can reasonably be expected of the new solution.

The great favour with which performance tests are regarded stems from the notion that somehow they can be an entirely reliable means of evaluating any solution that may be offered for a particular requirement. Given adequate knowledge, such reliability might be achieved. Frequently, in order to keep tests within reasonable bounds of cost and complication, it is necessary to limit the factors and conditions the test will simulate, relying upon the known correlations between those that are included in the test and performance of the products or solutions available. This means that new products may

be falsely rated; that is, the kind of tests, as well as the conditions selected, may turn out to be product dependent. This will often require that research be done to establish the validity of the test for new products.

It is necessary to conclude that, while the listing of performance requirements is almost always a useful exercise, it is often impossible to find suitable tests to serve as a practical and adequate basis for performance evaluation. Although continuing efforts must be made to devise and develop performance tests, it must be appreciated that the primary limitation will always be the extent of the knowledge available about the particular conditions to be imposed in service and their influence upon the products involved. In short, extensive research may be needed in support of standards preparation.

Evaluation of New Products

The evaluation of new products is a most difficult matter. The hope that performance tests might assist can readily be appreciated. They can be helpful but should always be backed by other evidence, the most convincing being proof of satisfactory service. Such proof is seldom available for new materials. It becomes necessary to rely heavily upon the exercise of professional competence. In short, knowledge and judgement based on experience must be applied to any and all relevant information, which can be gathered from any experience in use and from such tests as are practical. Once again, the real limitations are largely due to a lack of knowledge.

The need for as much knowledge as possible to aid in the interpretation of test results places a severe limitation on the extent to which the designer can rely upon others not familiar with his design to evaluate materials, components and systems. It is frequently proposed that a competent central agency ought to be able to provide evaluations. A concentration of knowledge and experience could certainly be developed and maintained. The evaluation, however, would always be limited to the conditions of use envisaged at the time. There is also the awkward problem of professional responsibility, and whether the designer can properly delegate decisions. The evaluating agency may also be in a difficult position if it finds it has incurred responsibility without control or even knowledge of the way its advice may be applied.

In principle at least, the designer ought always to know as much as possible about the materials and situations he deals with, since someone on the design team must be able to judge whether the specific application proposed introduces any new factors that would render invalid any evaluations provided by others.

There are a number of schemes for evaluation assistance to designers and others. Most are arranged to provide the user with an opinion from the evaluation authority that the product satisfies code or standards requirements or will perform satisfactorily when used as described. One scheme in Sweden, called "ER" (Egenskapsredovisning - Quality Declaration), is worthy of special note since it is directed towards providing the designer with as much information as he is likely to be able to use in making his own decisions. It can be extended and maintained indefinitely for old as well as relatively new products. Other schemes based on the opinion of some authority, such as Agrément, have now been developed in a number of European countries and are usually limited to new products, with certificates issued for three years and renewed for another three. After that time it is anticipated that the product, if useful, will have gained acceptance and be covered by product standards.

The Agrément schemes do not appear to have been unqualified successes. Their development has been slow in most cases where they have been applied voluntarily. That in France, by far the largest and covering many hundreds of products, has recently been modified for reasons which are not yet evident.

Conclusion

It is reasonable to suppose that standards, particularly product standards, are not yet used to the extent desirable as aids in the control of quality and performance. Certification of compliance with standards in common use would no doubt be offered by manufacturers if seriously demanded by designers.

Standards can never be a substitute for adequate knowledge on the part of the designer, or more properly, on the part of the design team. There must always be recognition that those who prepared the standard could only deal with the expected application. Unique features in a particular application call for special assessment and, in turn, adequate knowledge of what is involved.

The situation in relying upon evaluations by others of new materials or new applications is comparable to that in the selection of standards. Evaluations can only relate to use in the manner stated or implied. There must be knowledge to identify when the application differs and what effect that difference will introduce into the performance. When either the product or the application is new, the evaluation must represent a judgement based on knowledge of related situations without benefit of direct experience. This is the situation also in selecting tests to be carried out and in evaluating their results in assessing quality or performance. There is no substitute for knowledge and good judgement on the part of the designer, as is true also for those who prepare codes and standards.

PART III: CODES AND STANDARDS ACTIVITIES OF THE DIVISION OF BUILDING RESEARCH, NRC

In the course of its work on behalf of the construction industry the Division of Building Research has incurred an involvement in standards that is both extensive and diverse. The description of these activities and some of the considerations arising from them is not inappropriate as background information about standards, and may promote further understanding of them.

The Division has been in existence for 24 years, having grown steadily to its present staff total of 230, and is still the only agency in Canada engaged in a substantial and comprehensive way in carrying on research in support of the construction industry. The industry is large and diverse, the total value of construction representing almost 20 per cent of the gross national product and involving users, owners, designers and regulatory officials as well as manufacturers, suppliers, contractors and trades contractors. The Division has been concerned also with putting information to work, as well as with the development of new knowledge through research. It has therefore welcomed an information and advisory role in combination with its research role.

One of the more effective and more immediate ways of putting certain kinds of new information into use is through the improvement of standards. For this and other reasons the Division has always responded readily, within the limits of its resources, to opportunities to participate in standards work. A further link between the Division and standards work has been the special responsibility it carries to provide technical and secretariat support to the Associate Committee on the National Building Code and to the Associate Committee on National Fire Codes. This has served not only to provide an enhanced interest in normal participation in standards preparation but has unavoidably led to a strong interest in standards policy, promoted in part by the wide range of contacts developed on this continent and abroad in the interests of the National Building Code and the National Fire Codes.

Service to the National Building Code

The introduction of the first National Housing Act in the mid-thirties led quickly to a recognition of the need to promote uniform building regulations in Canada. The municipalities were permitted in all cases by their respective provinces to enact building bylaws, and this led to independent development of hundreds of different sets of regulations. The decision was made to seek improvement through the preparation of a national model building code offered voluntarily to all

municipalities as a basis for their bylaws. The first such code was prepared by the National Research Council, with sponsorship from the Department of Finance, and was issued in 1941. The need to update and improve this code was recognized, and responsibility for it was assigned to the Division of Building Research, which was established under the National Research Council in 1947.

Although the idea of proceeding towards uniform legislation by the preparation of the best possible model code was never seriously questioned, much attention was given to who should be responsible for it. The Associate Committee on the National Building Code was established for this purpose in 1948. It has 21 members appointed by the National Research Council, selected to provide a balanced representation of interests from across the country. This Committee makes the final decisions on all matters of content and policy. All members serve without salary, acting as individuals and not as representatives of any organization.

The Associate Committee is assisted by a number of Standing Committees whose chairmen also serve on the Associate Committee as ex officio members, with Sub-Committees and Revision Committees under them. In this way additional assistance is obtained from a large number of individual experts in the various fields of interest. Membership on all these committees and other background information can be found in the introductory section to the National Building Code 1970.

The staff of the Division of Building Research, though heavily involved in providing information for the decisions made about the Code by the Associate Committee and its various Standing Committees, do not normally serve as members. Technical liaison is provided by the appointment of a research adviser to each committee and a committee secretary is provided from the staff of the Codes Secretariat maintained by the Division. The officer in charge of the Codes Secretariat serves as the Secretary to the Associate Committee.

A consulting structural engineer serves at present as Chairman of the Associate Committee. It is intended that the practice of having a Chairman from outside NRC should be continued, though for the first 22 years the Director of the Division served as Chairman, thus ensuring close liaison with the Division. This link is now provided through the Head of the Codes and Standards Group of the Division, who serves as the Deputy Chairman of the Associate Committee. He is responsible for the Codes Secretariat and the Codes Technical Section as well as for coordination of the technical support provided by research

advisers and others from the various research Sections of the Division.

Revisions of the Code are now published annually, and a new edition is prepared every five years. The Division provides the total administrative support and manages the preparation, production, distribution and servicing of the Code and its numerous supporting documents. This includes all printing and all correspondence with municipalities and others as well as with Committee members. An onerous task is the circulation of drafts of revised editions of Code sections. Their availability is always advertised and comments are invited. As many as 2,000 copies of some parts have been sent out on request. All comments are processed and collated by the staff for consideration and resolution by the appropriate committees.

On the technical side the activities carried out on behalf of the National Building Code correspond quite closely to the Division's general objectives of providing an information, advisory and research service to the construction industry. Technical input to Code committees can be a direct and rapid way of putting much new information to work in the interests of improved building. In the reverse direction, work on the Code indicates where deficiencies in knowledge lie and serves to identify many useful research projects for the Division. These are brought directly back to the research Sections by the research advisers. Questions about the Code are answered on behalf of the Associate Committee. The technical staff welcome also the opportunities that arise to write and to speak on the technical aspects of the Code, often sharing the load with the Code Secretariat when administrative or legislative matters are involved.

Participation in the work of the National Building Code leads to a substantial number of commitments for committee service, attendance at annual meetings of associations, and lectures and talks. These are too numerous and varied for useful discussion here, but they may be identified in part from the list of the Division's committee memberships (5) which can be made available on request.

National Fire Codes

An Associate Committee on National Fire Codes was established in 1956 under the National Research Council to accomplish for municipal fire bylaws what the Associate Committee on the National Building Code does for building bylaws. The Committee is established and serviced by the Division in a similar manner, apart from differences in

scope and scale of effort. Committee secretaries are provided by the Codes Secretariat, and research advisers are provided from the professional staff of the Division. A Municipal Fire Department Code was produced in 1961 (6) and a Municipal Volunteer Fire Department Code in 1962 (7). These documents are models for bylaws establishing municipal fire departments. The National Fire Code of Canada 1963 (8) resulted from the first attempt to produce a comprehensive model fire prevention bylaw for use by municipalities.

Jurisdictions for fire are complicated by the existence in almost all provinces of Fire Marshals or Fire Commissioners operating at the provincial level. Thus, there may be rather loosely coordinated requirements covering fire safety from both building and fire bylaws at the municipal level, and additional regulations coming from the provincial level. Correlation of the National Building Code and the National Fire Code assumed that the necessary characteristics of the building would be determined by the Building Code, and that fire prevention and fire fighting matters, which came into being when the building was put into service, would be matters for the Fire Codes. There are obvious complications in provinces and municipalities where these assumptions are invalid.

The changing character of some modern buildings has now introduced further considerations into the need for correlation of Building and Fire Codes. These arise most acutely at present in tall buildings, where evacuation cannot be carried out before fire fighting begins. Fire fighters may also have to depend increasingly on the fire fighting facilities provided as part of the building. Revision of the National Fire Code must now take these and other matters into account so that it is at least compatible with the National Building Code. The Head of the Codes and Standards Group of the Division has recently been made Deputy Chairman of the Associate Committee on National Fire Codes to ensure adequate liaison with the Division and with the Associate Committee on the National Building Code.

Contributions to Standards Preparation

The Division has always regarded committee activities leading to standards preparation as an appropriate and useful way of contributing towards improvement of building. The problem has been to make a rigorous selection of committee assignments in order to keep the commitments within reasonable limits in relation to the research program. The policy has been to accept invitations when the Division is in a special position to contribute and to obtain some benefit in return.

As a result, Committee memberships reflect many of the areas of research where the Division has special expertise. These also, in many cases, have been problem areas since this has always been one of the main reasons for undertaking particular lines of research.

The contributions to Standards preparation range quite widely from the provision of specific information required for some part of a particular Standard to assistance in planning and policy committees. The basic requirement is for knowledge of the subject area involved. Expertise in test methods and measurement is almost always valuable, since standards are usually of little value unless requirements can be established in measurable terms. Research and development of test methods themselves become important activities. Assignments accepted on behalf of a committee may include experiments on points of special interest, trials with proposed test methods, and participation in round robin schemes for evaluating test methods and requirements.

The Division currently holds 92 committee memberships on 75 committees and sub-committees of the Canadian Standards Association. These include two advisory committees and six sectional committees concerned with planning, policies and direction of standards preparation. The majority of the committees are concerned with materials, elements and components of buildings, and relate to quality and functional performance. Others are concerned primarily with the provision or regulation of safety through ultimate adoption by provincial authorities. All are voluntary at the time of preparation and have no legal status until adopted in legislation or in contract documents.

The Division participates in the work of 28 Committees of the Canadian Government Specifications Board. The specifications prepared by these committees are, with a few exceptions, concerned with commodities or products since they are used in the first instance for government purchasing. In many product areas they are widely used and accepted as national standards.

The Division holds 100 memberships on standards committees of various kinds outside Canada. Eighty-seven are American, and of these 58 are in the American Society for Testing and Materials. The work with ASTM is concerned in large measure with methods of test, although much of it is also concerned with materials standards. The development of performance standards for components of buildings has been heavily supported by the Division through work on ASTM Committee E-6, Methods of Testing Building Constructions and its various Sub-Committees. The relatively small number of Standards of this kind already developed, despite a substantial effort and great current interest, is an indication of the difficulty.

Much applied research by the Division on the performance aspects of walls and windows in respect of heat, rain and air leakage has gone into the preparation of ASTM Test Methods. Corresponding contributions have been made in respect of acoustics, fire, structures and soil mechanics, as well as a variety of building materials. Five members of the Division have served as committee chairmen.

On occasion test methods have been devised and employed first in Canadian Standards. Usually, however, such developments have tended to take place first in the United States, to be adopted later for Canadian use. There is no equivalent in Canada of ASTM, in which the building research worker can work with highly knowledgeable people in the professional research atmosphere of a prestige technical society, sharing knowledge and experience in particular fields while working towards the formulation of the best possible test methods and standards.

Membership participation in another American technical society, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, has created additional unusual opportunities for officers from the Division to observe and to learn about the very extensive industry standards developments in the United States. The Society itself, though serving a multi-billion dollar industry, confines its standards activities to the preparation of standard methods of measuring equipment performance. Notable exceptions to this are the Refrigeration Safety Code and the Thermal Comfort Standard. ASHRAE Standards, though entirely voluntary, usually find widespread application throughout the industry, generating a large measure of agreement and uniformity. Industry then prepares the equipment performance rating standards by which the business of the industry is carried on, employing these and other generally accepted test methods.

Industry standards may then be submitted to the American National Standards Institute (ANSI) for processing and review by special committees. In this way large numbers of industry standards, of which those of the American Gas Association are a good example, are confirmed as acceptable National Standards. Some industry standard test methods, such as those of the Underwriters Laboratories Inc. in the fire field, have been processed by ASTM and ultimately issued as ASTM Standards, with the added prestige that ASTM's independent position gives. Many of these industry standards are undoubtedly often borrowed for Canadian use, with or without official recognition. Many of the rating figures quoted for consumer goods, such as refrigerators, air conditioners and dehumidifiers, are often based on US industry standards.

The Division has become involved through participation in CSA in a number of international standardization activities, principally in the fields of paints, acoustics, documentation and fire. Canadian representation at the meetings of the Committees of the International Organization for Standardization (ISO) on these subjects has often been provided by the Division.

Other NRC Contributions to Standards

Other Divisions of the National Research Council also contribute substantially to standards in Canada in accordance with their various interests and responsibilities, some of which have relevance to building. The Division of Physics maintains Canada's reference standards for the basic units of measurement, involving mass, length, time, temperature, electric current, and luminous intensity. This responsibility has led to active participation in international and national committees in which various aspects of these basic standards are taken up, as well as the more practical standards developments arising from these and other interests of the Division. As an example, a strong interest in light has led to participation in colour standards work. The Radio and Electrical Engineering Division becomes involved in both the fundamental problems of reference standards and methods of measurement and the practical requirements of working standards, including the Canadian Electrical Code with its associated standards.

The Division of Mechanical Engineering has had a very extensive involvement through its Fuels and Lubricants Laboratory in the many specifications developed for Government purchasing through CGSB. Some of these have relevance to building. Correspondingly, the Textiles Section of the Division of Chemistry has participated strongly in CGSB specifications, a number of which are linked to building because of fire considerations. These references are not exhaustive, even in respect of activities having some relevance for building. The "NRC Review 1967" (9) may be consulted for the most recent listing of NRC service on outside organizations. A brief description of a recent development, the establishment of an Associate Committee on Scientific Criteria for Environmental Quality, can be found in the President's Report for 1970-1971 (10). A supporting secretariat for this Associate Committee has been established in the Division of Biology.

Testing and Calibration Services

Although the National Research Council has always welcomed an information, advisory, and research role in support of standardization, it has no responsibility for enforcement of regulations. It has resisted pressures to become a routine testing agency, but has not hesitated to

provide essential calibration services to assist in measurements of all kinds and to make its test and experimental facilities available on a commercial basis when they are not available elsewhere in Canada. The wide range of such services will be evident from the NRC Schedule of Fees for Standardization, Test Work, etc., (11) which is available for study.

While these services are regarded primarily as aids to scientific and industrial research and thus would be provided primarily to manufacturers for development purposes, it will be obvious that some of them are required for other purposes which cannot be ignored. Because of the nature of its work the Division of Building Research, in particular, finds its large-scale test equipment, for fire, acoustics and heat, air and rain leakage, in demand for testing to established Standards in support of promotional claims or to determine compliance with regulatory and contract requirements. There is little or no demand for structural tests, since there are two dozen or more large structural test laboratories throughout the country. Some testing, such as that on sealed double-glazing units, is done initially by the Division until facilities become available elsewhere. This is welcomed when the early testing to a new or tentative standard may still carry some element of research. There is always the possibility, as has occurred in the testing of insulation materials and building papers, that alternative facilities are not developed and the Division must continue to provide the service.

There are difficulties as well as advantages in combining a testing role with an advisory and research one. There are obvious economies, particularly when the facilities are costly and the services are rather special, but there can be incompatibilities between facilities for research and those for a steady line-flow testing operation. Ratios of research to technical staff may differ widely. Testing tends always to be urgently required, and tends to displace research unless separate resources are assigned to the two functions.

Less tangible but still very real difficulties arise because many people become confused between a testing role and an advisory and research one. They tend to assume that the association of the name of NRC with the test result somehow guarantees the performance of the product in question, or even that NRC is approving the product for their use. A more common assumption is that somehow the test result provided always represents the product as now manufactured and as it will be in the future. The fact is that NRC does not endorse, recommend, or approve any proprietary product. Commercial testing is carried out on the product the proponent submits; it may or may not be from regular production.

NRC can only certify in any test report as to the results obtained from the tests carried out as indicated. Listing, labelling, or other forms of certification of compliance with some standard which some other agencies are able to provide are applicable to continuing production only to the extent that they are based on examination of representative samples and that suitable quality control is being maintained.

Conclusion

This review of the standards activities of the Division of Building Research, with the further brief reference to other Divisions of the National Research Council, indicates the strong link that exists between applied research and the standards-making process. This is particularly true for the building field, in which much of the new knowledge developed through research directed towards the solution of building problems has direct relevance to standards. The Division continues to play a key role; it is in many cases almost the only source in Canada of certain kinds of building science expertise. Even if the National Building Code, for example, were prepared under other auspices, it would still be highly desirable for the Division to be heavily involved.

CONCLUSION

It has been the object of this paper to provide a useful background for the many discussions currently in progress about various aspects of standards. Implicit in the presentation is an attempt to identify the factors that determine the need for standards and the ways in which, once prepared, they are used. No clear-cut answers have been found. It can be said that standards are generally prepared in response to some recognized need, but there must always be sufficient information or experience or knowledge to permit a useful standard to be prepared. Standards will not have an influence merely because they exist. The initiation of standards must always, therefore, be decided by reference both to those who can identify the need and to those who can assess to what extent the need is likely to be met.

The requirement for standards arises in many ways. The most common is probably the recognition by either suppliers or users, or both, of the timeliness of a venture in standardization of some particular product or practice. Such standards may have an influence if there is a genuine concern for them through voluntary adoption without any great effort to enforce their use or to check on compliance. Other standards may be prepared because of a unilateral government demand for standards for purchasing or for some form of regulation such as that for safety. These, too, may have the desired influence when largely complied with as a matter of conscience or through fear of detection of failure to comply, with no more than casual policing.

The recently published history of the Building Research Station in the U. K., Science and Building, (12) contains many references by the author, Sir Frederick Lea, who was the Station's Director for 20 years, to difficulties or problems recognized by the industry, studied by the Station and finally resolved by the preparation of the necessary standards or codes of practice required to put the findings to use. This reflects a mature approach in a country which has a well developed standards situation, but it is not typical of current Canadian practice. It exemplifies those dual prerequisites of standards preparation: need and knowledge.

Just as adequate knowledge is required in the preparation of standards so too is it needed for their proper use. The standards writer must know or attempt to anticipate the situation in which the standard will be applied. The "credibility" of the standard may depend on the reputation of the standards-writing agency, but its "validity" will always depend on the capability of those who were involved in its preparation.

Some product standards prepared largely as descriptions of agreed quality levels of certain goods that are widely used in a variety of ways may not, in the nature of things, provide any assurance of their adequacy for any one purpose. Other standards dealing with a product or class of products with a stated or implied function provide some assurance that what is called up will function as proposed. Performance standards, although highly favoured since they purport to deal directly with the desired end result, must also be regarded with some reservation since the disparity between the conditions examined and those committed by the design may be very great. This arises from the limitations of knowledge, costs, and other practical considerations upon the extent to which all the relevant factors in performance, under all possible applications, can be identified and assessed in the product under examination. Performance tests on which performance standards depend may at best be no more than an examination conducted in a standard way under an agreed set of conditions to assist in comparing and selecting from a range of products and in judging whether the product selected will perform as required in the application contemplated.

This inherent limitation in the relevance of a standard to a particular situation may vary widely. It is always necessary for the designer to assess it. One of the great challenges in standards preparation, and one not at all well handled at present, is to provide the user with as clear a statement as possible of the application and limitation of a particular standard so that he may judge his own situation. The ability to exploit knowledge, judgement and information arising out of other situations will always be conditioned by uncertainty regarding their relevance.

The great interest in approval of materials, components and systems must be seen as the result of a need for assistance based on judgement, in the absence of adequate knowledge and experience on the part of the potential user. The ability of the central evaluating authority may also be limited, with serious implications for the relevance of the approvals given. The fact that a judgement is the best possible may be satisfactory in man-made law, but it may still fail to ensure compliance with nature's laws.

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