Fire research at the National Research Council 1960

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NATIONAL RESEARCH COUNCIL
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BY

G. W. SHORTER

FIRE STUDY NO. 4

OF THE

DIVISION OF BUILDING RESEARCH

OTTAWA

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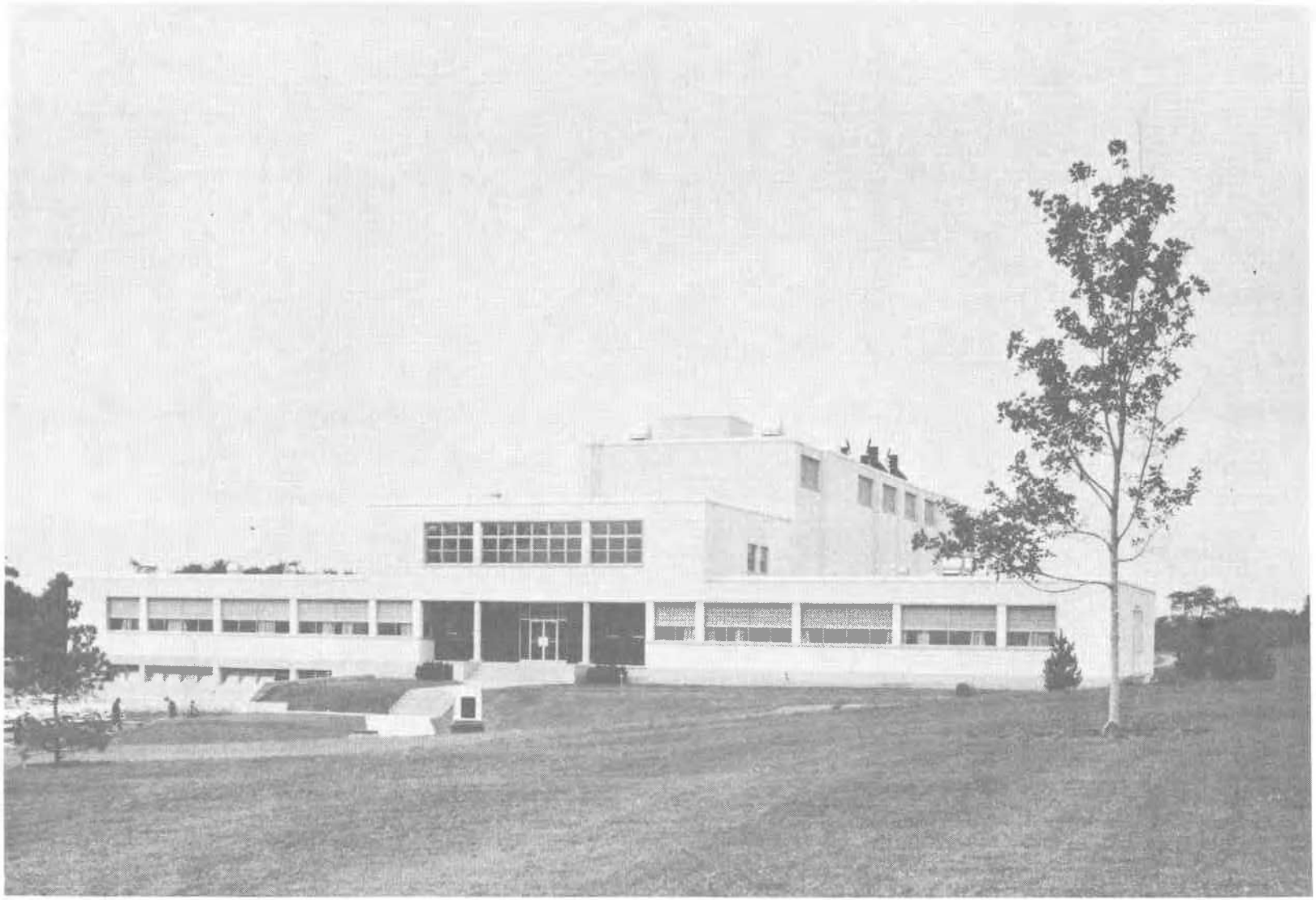

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The Fire Research Building of the Division of Building Research,
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Presented to the Association of Canadian Fire Marshals on 5 July, 1960, Banff, Alberta

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The Fire Section of the Division of Building Research was established approximately ten years ago with the object of conducting research aimed at a reduction in the life and property losses by fire in Canada. In order to achieve a real over-all reduction in property losses it was realized that any remedial measures suggested must not involve undue expenditure nor introduce problems of subsequent operational efficiency.

Much of the work undertaken in the Fire Section is formulated within the Division itself as a result of general considerations of the fire situation in Canada. Many problems continue to be brought to the attention of the Section from sources such as the Associate Committee on the National Building Code, fire officials, government departments, industrial companies and private individuals. Inquiries have also been received recently both from the United States and overseas countries.

PROGRAMMING OF WORK

In establishing a program of research, priority is given to Canadian problems that are of most importance from the national standpoint, although not necessarily unique to Canada. Thus high priority is usually given to problems associated with building code requirements as it is through building regulations that the greatest progress can be made in effecting better protection from fire to buildings and their occupants. Accordingly one of the prime functions of the Fire Section is to provide factual information upon which decisions concerning building code requirements may be based.

The solution of many of the problems submitted by outside agencies often requires only a literature survey. The Fire Section has been able to provide such an advisory service without seriously interfering with its major laboratory activities. It is clear that a good library facility is necessary for providing this type of service in addition to providing essential background material for laboratory research projects. The Fire Section is now receiving library material from almost every organization working in the field of fire research throughout the world and already a fairly extensive collection of literature has been assembled.

It is not always possible to undertake immediately the experiments which are necessary to provide solutions to the remainder of the problems received. In these cases priority is established after consideration of the importance of the problem in its own right and of the possibility that the solution might have a more general application. The choice of work is in no way governed by its academic interest. Thus emphasis may often be given to those problems for which the solution is theoretically simple and yet will provide a valuable contribution to the field of fire protection.

STAFF AND FACILITIES

In order to carry out comprehensive research studies it is necessary to have a number of different academic disciplines represented on the staff. Even at this early stage in its development, the Fire Section has members of staff who are proficient in the fields of physics, chemistry, chemical engineering and mechanical engineering, as well as in the actual practice of fire-fighting. A great advantage enjoyed by the Fire Section is that it constitutes part of a large research organization wherein assistance may be obtained on special problems

from experts not only in the Division of Building Research but in other divisions of the Council. The co-operation of the Divisions of Mechanical Engineering, Radio and Electrical Engineering and Applied Chemistry has often proved most valuable. The computing facilities of the National Research Council are also available for handling problems involving cumbersome mathematical solutions.

Although a competent staff is the essential feature of any research organization, it must be provided with suitable facilities in order to pursue experimental investigations. The Fire Section is privileged to have available to it a large new laboratory building devoted exclusively to fire research (1). The Fire Section is gradually acquiring special apparatus if commercially available or constructing such equipment when necessary. It has often been necessary to adopt this latter procedure, particularly for thermal radiation measurements and the determination of the physical properties of materials at high temperatures. Thus a great deal of staff time is of necessity spent on the development of special instrumentation and apparatus.

Last but not least, it should be emphasized that information obtained at actual fires is used wherever it is applicable. Included among these field studies was the St. Lawrence burns operation from which most valuable results were obtained.

TYPICAL STUDIES

Fire Fatalities

One of the major investigations has been a study on a statistical basis of fire deaths in Ontario. In carrying out this work, which was begun in 1954, the Fire Section has enjoyed the full co-operation of many agencies such as the Ontario Fire Marshal's Office and that of the Registrar-General of Ontario. What has been equally gratifying is the co-operation received from hundreds of individuals,

particularly fire chiefs, who have conscientiously completed the necessary report forms. In this survey each case is classified in one of four primary categories, depending on whether the victim was a child or an adult, and whether the fire was a building fire or a clothing fire. Inquiry has been made into every aspect of death due to fire that can possibly be treated statistically. To date this study has been reported on mainly in internal reports of the Division, copies of which are sent to all fire marshals with the exception of the short paper, Fire Deaths in Ontario by G. Williams-Leir, presented at the Fire Research and Fire Prevention Conference held prior to the opening of the Fire Research Building in October 1958 and since published in the proceedings of the conference (2). Although reporting has been on a consistent basis for only four years, consideration is being given to the publication of a paper later this year in the belief that reliance can be placed on certain trends indicated to date.

St. Lawrence Burns

The largest study so far undertaken by the Fire Section was the St. Lawrence Burns Operation. A complete set of reports on this operation has been sent to all fire marshals, with reprints of the paper which appeared in the April issue of the NFPA Quarterly (3). This study furnished factual results which would have been difficult to obtain in any other way. The radiation records in particular have provided a firm basis for establishing requirements for the spatial separation of buildings.

The results of smoke measurements emphasized the hazard of smoke with reference to the escape of occupants from a building. It was shown that smoke can seriously reduce visibility in an extremely short time. For example, an open upstairs bedroom in a dwelling can become "smoke-logged" in two minutes. It would therefore appear that

from the standpoint of life hazard, an effective fire detection system should be based on the early detection of smoke. In spite of all precautions, however, it is probable that smoke in stairwells and corridors will still be a problem in large structures with high occupant loads, such as schools and office buildings. Studies are being undertaken into means of keeping smoke out of escape routes in this type of building. The Fire Section is interested in this problem and will be studying the use of slightly increased pressures in such areas while at the same time having the fire area vented.

Other results from temperature measurements provided confirmation of the validity of the standard time-temperature curve used in fire endurance tests of walls, floors and ceilings. The results indicated that the temperatures are generally higher than those given by the ASTM curve where there is a high fire load or where flammable interior finishes are used. Other factors studied included the effect of wind in producing higher radiation intensities on the leeward side of a building than on the windward side. This effect is vividly shown in the coloured films which were taken at each of the burns. The careful planning of these experiments provided results which have wide application.

Under rare circumstances, observations at fires permit spot checks to be made which are valid for the particular circumstances prevailing. Of the many fires investigated over the years by the Fire Section, two have given results which are relevant to the ignition of materials by radiation. It is interesting to note that these results and those of other fires reported by the British Joint Fire Research Organization have agreed with the general radiation theory derived from the St. Lawrence results.

Fire Endurance

The largest facilities in the Fire Research Building are those associated with the fire endurance testing of building elements.

The two large furnaces serve a dual role in that they are used not only for carrying out standard tests but also for research. A study has been carried out for example on the effect of restraint on the fire endurance of walls. These experiments are important when considering whether a wall tested as load-bearing should be assumed to have the same fire endurance as the same wall tested while fully restrained on all sides, as is necessary if it is to be employed as a non-load-bearing wall. Results from tests on the floor furnace have given useful information on the load at failure of floors and beams. Experiments have been carried out to determine the most appropriate method of measuring temperatures on the unexposed surface of a specimen during a test. Extensometers have been designed and installed to measure the expansion of walls during fire tests, as well as instrumentation for measuring the deflection of floor slabs. A conditioning chamber has been designed and installed to facilitate the curing of specimens prior to test.

In order to reduce the number of these cumbersome and expensive tests in the future, one research study is concerned with the prediction of fire endurance. Such a procedure would greatly facilitate the development of new constructions by industry. Similar studies have been going on in various countries for a number of years but all of the methods so far proposed have definite limitations to their use. In some cases, their use would result in inaccurate predictions. Various analytical and numerical methods are being studied by the Fire Section, in order to predict the time of both the thermal and load failure of building elements during the fire test; the results are promising. When applying these methods one has to know the physical properties of the materials used in the construction being studied. Unfortunately very little information is available on the physical properties of materials at elevated temperatures. It has therefore been necessary to design and construct apparatus to obtain this information. These properties include

the strength, specific heat and thermal conductivity. When this procedure for prediction is fully developed it should be possible, following a large-scale test, to predict the fire endurance of a similar construction for different thicknesses of materials and possibly for different materials.

Fires in Corridors

The importance of the spread of flame characteristics of a building material has been appreciated for a number of years. Little information is available, however, as to how the results of the various flame-spread tests should be applied. A modest approach to this problem has been made by the Fire Section by considering corridors as a start. The main reason for this choice of building element was the fact that corridors differ from almost all other compartments in a building in that they are characterized by a lack of furnishings or other combustible contents. A small-scale test model has been constructed for examining the spread of fire characteristics for combinations of wall, floor and ceiling lining materials in corridors. The test fires originate in a model room opening on to one end of the corridor. Ventilation conditions have been arranged to be close to the optimum for the propagation of the fire to the end of the corridor. The criterion which has been adopted is that an assembly shall be considered unsafe if a fully developed fire propagates to the end or to a point near to the end of the corridor.

Approximately thirty such tests have been carried out. Based on these studies it is recommended that a composite index be used for determining the over-all requirements for flame-spread ratings for wall, ceiling and floor finishes. One interesting aspect of this study has proved to be the influence of floor coverings on the propagation of a fully developed fire along a corridor. Recent Danish full-scale

tests in the same field confirm the idea that the picture so far obtained will be applicable to full-scale cases (4).

It is possible that the Fire Section may carry out full-scale tests at a later date in order to substantiate the results of the small-scale tests, although there is no reason to doubt their validity. Such full-scale tests would be used in addition to study the effectiveness of sprinklers in stopping or retarding the spread of a fully developed fire along a corridor. The Section has been concerned to date with corridors because they tend to present a relatively simple problem. It is probable that large areas such as auditoria may be studied in the future to determine if a somewhat similar approach might be practicable.

Combustion

A number of experiments have been carried out on problems of combustion including some on the ignition of combustible material adjacent to steam lines, and on the self-heating of lime-treated wood shavings. Much time has been devoted to the design and construction of a small furnace to be used in the application of a test method for determining whether or not a material meets the requirements of incombustibility set forth by the Associate Committee on the National Building Code. The Section has participated in a round robin series of tests on behalf of ASTM Committee D20 concerned with determining the ignition properties of plastics.

A long-term project recently initiated is designed to develop general knowledge on various aspects of the combustion process as applied to building materials. The properties of materials to be studied include ease of ignition, evolution of gases as affected by rate and method of heat application, composition and flammability of the gaseous products.

Fire Extinguishment

One study in this field is concerned with the development of a small-scale fire test for mechanical foam. This study has been undertaken in order to obtain a more reproducible fire test. Due to the nature of this experiment, it has to be carried on out of doors at present, thus permitting wind to exert a considerable influence on the results. If a small-scale test can be developed, it will not only be much easier to carry out standard fire tests, but it will lend itself to carrying out research studies on foam. A laboratory foam generator has been constructed for this study. The variables being investigated are rate of application of foam, expansion ratio, concentration of foam liquid, 25 per cent drainage time and critical shear stress. A new approach has been taken in that a control time is determined which is defined as the time at which radiation from the fire is reduced to 10 per cent of the maximum value before application of foam.

Another long-term project is concerned with the use of fire retardants in forest fire control. Some laboratory studies have already been carried out and more are yet to be undertaken. It is obvious, however, that due to variation in the fuel found on the forest floor it will be necessary to perform a number of field trials before any conclusive results may be obtained.

APPLICATION OF RESULTS

Probably the most important medium through which results of the Fire Section's work find application is in various codes and specifications, a notable example of which is the National Building Code of Canada. Although the Section is not directly responsible for the writing of any code or specification, it frequently provides essential information upon which code requirements are formulated. A description of the relevant work is either published or prepared in report form and

circulated to others interested both in Canada and elsewhere. Where work has been originated within the Section, similar reports or publications are prepared, and these are also sent out to interested authorities.

The results of work initiated in response to an inquiry received from an outside organization or individual are immediately made available to the parties concerned. Where the results are thought to have a wider application, appropriate publications may also be prepared.

CONCLUSION

It is hoped that this summary shows that the work undertaken by the Fire Section provides a rational approach to fire problems. It is the Section's desire to assist wherever possible in the solution of fire problems, with the hope that definite improvements will be made in the fields of fire protection and fire prevention. One of the primary aims of fire research is to enable more effective use to be made of building materials and construction techniques through increased knowledge of their characteristics in relation to fire.

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