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Builders and building owners continue to face serious problems of rain penetration, ice build-up under soffits, frozen pipes in insulated cavities and condensation in various parts of the building enclosure. The Division of Building Research of the National Research Council of Canada, in cooperation with the Canadian Committee on Building Research,* has undertaken a study of the construction process to determine why so many buildings experience serious water and air leakage in outside walls, around windows and through roofs. In conjunction with the study, the Division investigated how building science information is used by the construction industry and how the industry could be served by research.

SCOPE OF THE STUDY

The study was conducted in the province of Alberta, mainly in Edmonton and Calgary, during July, August and September of 1980. On-site observations of construction activities, examination of construction documents, and interviews with designers, general contractors, subtrades and material suppliers were carried out on over 30 large projects. Some were existing buildings under repair, but most were new building projects. Visits were also made to a few construction sites in Vancouver, Yellowknife and Saskatoon.

THE BUILDER'S ENIGMA

During the course of the study it became apparent that, in general, many of the problems of the building envelope are caused not by the builder but by those who prepare the architectural or engineering drawings. The cause of many facade problems, for example, originates in the way in which materials are specified to be put together and the type of materials chosen for various parts of the construction envelope. Either from lack of appropriate information about the construction sequence or from incorrect assumptions of end performance, unsuspected weaknesses appear first in architectural and engineering drawings, are carried through to shop drawings and are eventually "built in" by the construction team.

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* The Canadian Committee on Building Research was formed in 1974 by the National Research Council of Canada "to provide an interdisciplinary forum for the stimulation and application of building science and technology in Canada with particular reference to the design, performance, and use of buildings."

Subsequently, if part of a building envelope does not function adequately, there is a tendency to question the builder's workmanship, not the design. A wall section or a construction detail that is incorrectly conceived from a performance point of view cannot function as expected, no matter how well it is built.

BUILDING SCIENCE

Conversations with professional builders, suppliers, subcontractors, and some owners revealed that building science is inadequately understood. But there is no shortage of curiosity or eagerness to learn; most of those in the building professions are receptive to, even hungry for, technical information. It was pointed out, however, that research information is often presented in a very complicated way and that those able to "translate" it and explain its significance are in short supply. This applies particularly to the application of information on new building practices, techniques, and materials. It was suggested that most building science publications would be much more understandable if they contained more examples and illustrations of how to apply theory to practice.

The bid process, and to some extent, competition, are significant bottlenecks in the transfer of building science information. Designers are reluctant to ask a particular builder for information about construction methods and techniques before tenders are closed. Similarly, because of the competitive nature of the industry, builders are reluctant to give information about their methods and techniques and to discuss their experiences with problems on past projects. (If builders did this, it would provide extremely valuable feedback about building performance.) Builders are rarely certain of the causes of the difficulties and do not wish to lose up-coming contracts as a result of what might appear to be poor construction practice. This situation places both the designer and builder in an awkward position, making it difficult to resolve construction problems, particularly building performance problems.

Improvements in methods of construction depend largely on the flow of information and experiences to and from the site. Research is collecting, digesting, analysing and processing information related to problems and their solution. Communication is a cornerstone of research. It is important therefore that ways be found to improve the communication between members of the construction team with regard to the design and performance of buildings. The construction team (builders and designers) would welcome more information about the actual performance of various design configurations, e.g., case histories of what "works," what does not "work," and why.

AIR BARRIERS AND VAPOUR BARRIERS

A major technical problem is the confusion about air and vapour barriers for walls and roofs. Few of the construction drawings that were examined illustrated or specified a requirement for an element termed an "air barrier", although most drawings indicated a "vapour barrier". In fact, a continuous air barrier is required in all cases and a vapour barrier may or may not be required. Each of these elements has a unique function and each must be designed to fulfill that function.

The principal function of a vapour barrier is to resist the flow of moisture that occurs by diffusion. Diffusion is a process whereby water vapour flows through construction materials in much the same way as heat flows through insulation. A vapour barrier does not completely stop the flow of moisture; it retards it to an acceptable level. Contrary to popular belief, a vapour barrier need not be continuous: small openings in it do not appreciably increase the over-all moisture diffusion rates through a wall or roof, but it must be placed on the warm side of the construction.

The principal function of an air barrier is to resist the passage of air. To do so it must meet two requirements: (a) resist the highest expected air pressure load that might appear over the life of the building and (b) be continuous. The first requirement is seldom considered; the second is confused with the function of a vapour barrier.

Even if an air barrier had been specified in some of the construction specifications, it was believed that the proposed construction method would not perform as intended. The methods, as outlined, would not meet the primary requirement of supporting the air pressure load, e.g., loads created by stack effect (differences in air pressure between exterior and interior air caused by temperature differences especially during winter), particularly in high-rise buildings, pressure due to high winds, or pressures caused by ventilation systems. The design requirements for air and vapour barriers need to be clarified so designers understand what they are trying to achieve.

Some general problems further complicate matters. Many of the traditional construction methods that performed adequately in the past do not perform so well today because of the increased requirements for insulation and the higher indoor humidities in many new buildings. The conditions impose greater thermal and moisture loads on walls and roofs; these must be carefully analysed at the design phase so that construction details will complement these more rigorous conditions. The influence of tradition in practice inhibits the changes required at the design level and in construction to achieve better performance of building enclosures.

COMMENTS

The construction industry is in need of more practice-oriented research, e.g., full-scale investigations of the thermal and moisture control performance of wall and roof assemblies. It is in immediate need of practical answers regarding this performance for many of the traditional designs now offered for construction. Because the design requirements (loads) for air barriers are somewhat ambiguous, and because there are inadequate calculation procedures for their design, the Division of Building Research is considering a research project to examine the construction and assembly sequence of some conventional construction details to determine if the air barriers can withstand predetermined air pressures, i.e., pressures caused by stack effect, and the effects of wind. The information should provide an indication of the adequacy of the design and of the construction procedure. The project should also indicate if further investigation is required.

Owners, designers and builders need to discuss technical performance more openly. It is recommended that the owners request a "reflection period" to follow immediately the close of tenders to allow the designer and builder to re-examine construction details with reference to the construction sequence and to verify building performance expectations. This reflection period might save owners many dollars in future maintenance costs and bring about important savings on capital cost.

The application of building science must take on new dimensions if it is to deal with the ever-increasing complexity of construction design. With the rapid development of new materials and new technologies, a designer is handicapped if adequate building science expertise is not available. Some designers and builders have developed special skills in this area, but there are not enough individuals with this knowledge to meet the present needs of the industry. Professional and technical societies serving the building industry could assist greatly with the application of building science by encouraging better communication between building scientists and practitioners.

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