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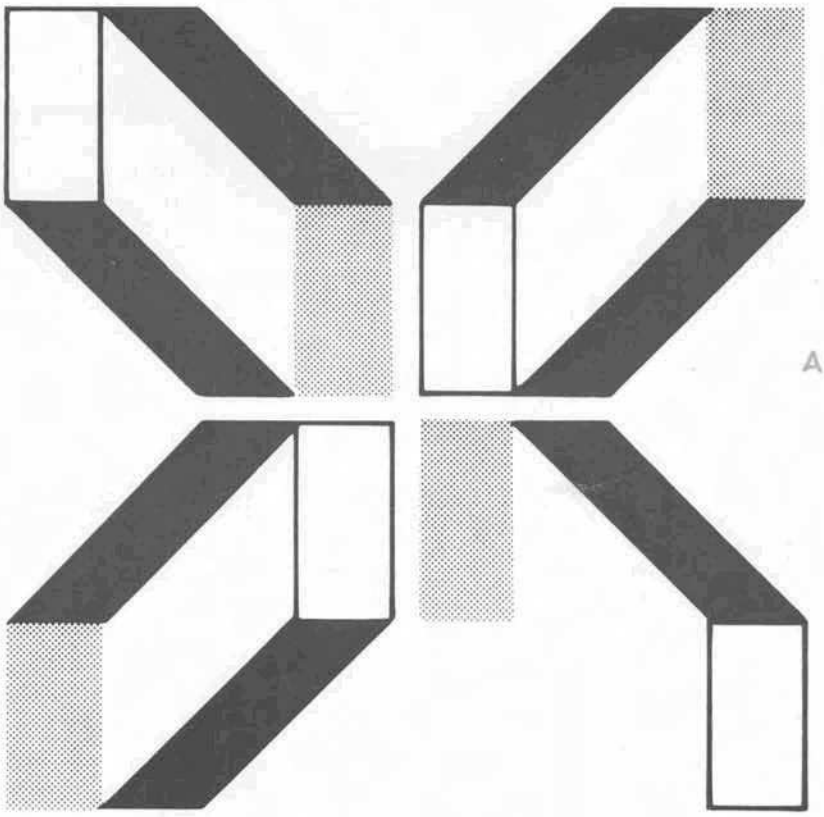

Canada

CONSTRUCTION-RELATED RESEARCH AND DEVELOPMENT STATISTICS FOR CANADA

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ABSTRACT

The sources of funding and the performers of construction-related research and development in Canada are described, as well as the difficulty of compiling comprehensive statistics at the national level. Current statistical deficiencies and past attempts at national aggregation are discussed. An analytical framework for construction-related R&D that could have general application is presented.

RÉSUMÉ

Ce document décrit les sources de financement et les exécutants canadiens de la recherche-développement en construction, et il fait état de la difficulté de dresser des statistiques complètes au niveau national. On y examine les déficiences actuelles des statistiques et les tentatives faites dans le passé pour en arriver à un "agrégat" national. Les auteurs présentent un cadre analytique de R-D en construction qui pourrait être d'application générale.

INTRODUCTION

In the literature one finds strong words of advice about ideal, minimal, and even achievable, future levels of national expenditure on construction-related research and development. Some of this advice consists of generalized rules based on the industry's output or the sums other countries spend. Less has been said, however, about the difficulties of identifying the R&D funding sources and performers, or about the linkages between R&D and the activity of construction, the supply of materials and equipment for it, and the satisfactory operation of built works. All these aspects are discussed here as they apply in Canada but, to some degree, the conclusions may well apply to other countries.

Much has been made of the tendency of companies (and governments) to underinvest in construction R&D. It has been argued cogently that, more often than not, actual private returns are well below potential social returns. In this report, it is assumed that such shortfalls are likely to continue even after more comprehensive statistics become available.

Most of the criticism for lagging construction R&D funding in Canada and in other countries has been directed at the government, especially at departments that have cut back support, sometimes significantly, over the last few years. Most of the criticism for lagging performance has been directed at private firms, as well as at the government. At the same time, it has usually been recognized that the small size and fragmentation of most firms in the construction industry, particularly in the housing sector, have

discouraged R&D activity.* Some recent attempts to encourage construction-related R&D have been linked to priority problem areas such as energy conservation or low-cost housing. In this report the incentives and disincentives that influence the level of construction-related R&D in this country are not discussed, although some are mentioned in passing.

This report's principal focus is the precision - or the imprecision - of our knowledge about what has been done and spent in Canada.

THE CANADIAN SITUATION

Although construction as an activity is quite adequately documented in national statistics, there are no reliable time series for national construction-related R&D expenditures in Canada. The four principal attempts that have been made to calculate such figures for particular years have succeeded only in establishing order-of-magnitude levels for what may have been spent. The first attempt was by Hutcheon,[1] the second by Boyd and Wilson,[2] the third by Revay and Associates,[3] and the fourth by Rakhra.[4] All four are discussed later in this report.

Difficulties in compiling good construction-related R&D expenditure statistics in Canada are linked to a number of circumstances, such as the following:

- in the private sector, a significant portion of construction-related R&D is apparently performed by various sub-sectors of manufacturing which do not always have construction, building or engineering as their prime markets;
- in the university sector, most construction-related research is performed by departments of civil engineering, but not all of the research done in these departments is necessarily construction-related;
- in the past, national aggregations for construction-related research in fields such as economics and sociology have been ignored because they were quite small; while they are still small (in Canada, at least), they are becoming increasingly important as areas of research in their own right;
- although the two sectors of the construction industry - building and engineering - differ with regard to their respective products, one may make use of R&D results generated for the other; but the government agencies and private firms involved in the research or the construction do not always make the necessary connections.

There is no R&D levy applied to the construction industry in Canada, as there is, for example, in New Zealand. While levy statistics would do little to solve statistics and compilation problems, they would serve to focus more attention on R&D activities involving the private sector.

Most construction-related R&D falls within three broad categories: materials, equipment, and techniques. The results of the first two are of

*A few of the development, contracting and project management firms in Canada are very large, but their influence on R&D funding and performance remains small.

prime interest to manufacturers, and the third to construction firms. In Canada, materials R&D is relatively common, but this is not so for equipment R&D, largely owing to the subsidiary status of many of the major equipment manufacturers and suppliers. Private work on techniques is also uncommon, even among the largest contractors.

Government departments and agencies, such as the National Research Council of Canada's Institute for Research in Construction (IRC, NRCC) (formerly the Division of Building Research (DBR)), and some industry associations do try to fill the gaps in requirements for new scientific and engineering information in the construction field. Work in the universities is hampered by the fact that there are few centres or institutes that specialize in building or construction research, and relatively few universities that sponsor conferences in the field. The non-profit sector tends to rely on contract work. Research done by the larger firms in the industry and by consultants tends to be short-term and related to specific problems, many of which begin with economic, rather than technical, considerations.

As noted in the Revay report,[3] the main sponsors of construction R&D in Canada at present are the owners of large-scale facilities for the extraction, generation and transmission of energy. Many of these facilities are provincially funded and operated; for example, Hydro-Québec, whose budget for construction-related R&D for 1983 was reported by Revay to have been $46 million, a sum equal, perhaps, to all other such R&D in the country for that year. However, in the energy field it is difficult to separate the portion of R&D that is truly construction-related from the portion that is not.

Government grants and tax-based incentives for industrial R&D have been in place in Canada for over twenty years. However, the main thrust of these programs has always been to encourage manufacturing activity. Until recently, R&D activities associated with construction have been ignored. Also, most industrial R&D policy studies have had the same manufacturing thrust. The exceptions include the reports by Hutcheon,[1] the Economic Council of Canada,[5] Boyd and Wilson[2] and, more recently, Revay[3] and the Construction Industry Development Council.[6]

Canada's federal statistics agency (formerly the Dominion Bureau of Statistics (DBS), now Statistics Canada) has published, and continues to publish, extensive time series on construction activity (for example, Ref. 7), but has had little to report on construction-related R&D. The same may be said about the provincially-based statistical agencies. Even the published statistics have been difficult to interpret because, with few exceptions, information has not been collected for construction-related R&D performed by the manufacturing sector. Also, performers in the construction sector have themselves been classified, for reasons of small numbers and confidentiality, under "other non-manufacturing" companies, a classification that includes computer services, management and business consultants, and labour organizations.

The first biennial survey of industrial R&D in Canada was made in 1956.[8] It covered nearly 2500 of the largest Canadian companies, of which 377 reported making R&D expenditures totalling $66 million during the previous year. The main activity was in transportation equipment,

electrical apparatus and supplies, and chemical products. The 20 "other non-manufacturing" firms, out of the 500 surveyed in this classification, spent only $700,000 among them.

The survey for 1965[9] is the only one in the series to date that has included a specific section directed at manufacturing firms with regard to "R&D intended to create or improve products or processes to be used by the construction industry", and calling for estimates of current expenditures for the year under survey. Questions were also asked regarding sales by firms of products or services for use in the construction industry and the number of R&D personnel employed. This section, which was published as an annex to the main questionnaire, was designed in collaboration with DBR, NRCC. Unfortunately, the detailed results were never published by DBS or NRCC, although reference to the total expenditure was made by Hutcheon[1] and the figure was used by Boyd and Wilson[2] and Rakhra[4] as the basis for their own estimates.

From 1970 to 1981, DBS/Statistics Canada surveyed all known performers of industrial R&D in odd-numbered years and a sample, including the leading performers, in even-numbered years. Since 1982, full surveys have been conducted every year.

Beginning with the industry survey for 1971, and for the next several full surveys, the questionnaires included a section linking R&D expenditures with the markets for which the companies' products were intended. The information collected in 1971 and afterwards was quite similar to that collected in the 1965 survey. However, the earlier survey asked specifically for estimates of the total current expenditures by companies on R&D performed in support of the construction industry. The later ones asked for estimates of current intramural expenditures on R&D (for products and processes) intended for several different markets, one of which was construction. In 1971, for example, some $6 million, out of total current intramural expenditures of $371 million reported by the responding companies, was spent for the construction market.[10] The corresponding figures for 1973 were $12 million and $443 million.[11]

Although the systems and techniques used by Statistics Canada to report on R&D activity in governments, the universities, non-profit laboratories, etc., are now more detailed and sophisticated, it is still not possible to identify the full range of construction-related R&D expenditures with certainty. Much depends on how the expenditure figures for the individual departments, agencies and institutions are interpreted. The same uncertainty exists with regard to sources outside Statistics Canada. For example, the Natural Sciences and Engineering Research Council (NSERC) publishes annually a full listing of its grants and other assistance for university research, but this information is not shown or summarized by subject area or university department.

ATTEMPTS AT NATIONAL ESTIMATES

(a) Hutcheon[1]

In Chapter 4, Part I of this report, Hutcheon discusses the funding of research. Of particular interest is this paragraph:

> "No comprehensive figures on research expenditures for construction (in Canada) exist. It is necessary, therefore, to arrive at estimates by piecing together such information as is available without extensive surveys. A special questionnaire circulated...in 1966 produced the information that about $9 million was being spent annually by industry on construction research and development. This amounted to 0.1% of total annual construction. A recent estimate suggests that the current figure may be no more than $6 million, which at current construction volume levels would be about 0.04% of total construction." (p. 1)

The $6 million figure was for 1971, and was taken from Statistics Canada,[10] as noted previously.

With regard to university spending in 1971, Hutcheon used the appropriate list of federally-funded grants to universities[12] and personal judgement to put the estimate of total federal research support for these institutions at $4 million. He considered this to be generous, suggesting that $3 million might be a more appropriate figure.

Hutcheon noted that annual expenditures within DBR, NRCC at about this time were around $4 million. After adding estimates for R&D expenditures by other federal agencies, and for industrial R&D support programs of the government, Hutcheon concluded that the annual rate of expenditure on scientific activities for construction in 1971 was not less than $20 million per year and might have been as high as $30 million. This latter figure represented 0.2% of the value of all construction activity during the year.[1]

(b) Boyd and Wilson[2]

In this report Boyd and Wilson attempted an estimate of national annual expenditures. They observed that:

> "...the construction industry may be narrowly defined to include designers and assembly contractors, or more broadly to include all firms that are linked to construction activities by information flows or through the financial system - namely, materials and equipment manufacturers, suppliers, owners, developers or realtors, as well as contractors, architects, engineers and other designers. This present study therefore takes into account research and development done in support of the assembly part of the industry as well as R&D associated with the material, equipment and services that are utilized by it." (Ch. 4, p. 46)

According to them, R&D expenditures, in Canada at least, were negligible in 1972 for the industry defined in the narrow sense, and most of the construction-related R&D was in fact performed in the manufacturing sector.

Boyd and Wilson also made use of the $6 million figure for industrial R&D taken from Statistics Canada[10] and assumed that this level also applied in subsequent years. From Statistics Canada,[13] the authors estimated that the federal government's current intramural expenditures in support of the

construction industry as broadly defined went from $12.2 million in 1972 to $14.7 million in 1974. Federal grants for construction research in the universities were estimated to be about $3 million for 1971-72, and grants to industry for 1972-73, around $2 million. From their own survey, the authors estimated that the research councils in Ontario and Alberta had, during the fiscal year 1971-72, performed construction-related research valued at $1.5 million.

From these figures, Boyd and Wilson concluded that the national annual level of R&D expenditures at the time their report was being written (1974) would be in the neighbourhood of $25 million, but that there was other, non-statistical evidence to suggest that this figure was low. Also, if it was assumed that the national R&D level actually approached 0.3% of total construction activity, the figure would be in the neighbourhood of $50 million.

(c) Revay and Associates[3]

This report was commissioned in 1982 by a federal Interdepartmental Committee on National Construction Research, Development and Demonstration. It is the most qualitative and descriptive of the four attempts discussed here. However, it was not part of the mandate of the authors to include more than "order-of-magnitude" national-level figures in their report.

The findings were based on the analysis of a comprehensive questionnaire developed by the Interdepartmental Committee for use by some 40 federal departments and agencies. Subsequently, Revay developed a set of questionnaires for potential respondents in provincial, municipal and territorial governments, educational institutions and private sector firms and associations. Over 330 responses were received and analyzed. Interviews were arranged with 128 respondents, and telephone discussions with some others. Information from other studies, and material from Statistics Canada and the Ministry of State for Science and Technology were also examined.

The expenditure data given in the Revay report are mainly for 1980, 1982 and the fiscal year 1982-83, and are, for the most part, estimates or rounded numbers. The most extensively studied sector was the federal government. However, some data have been double counted, for example, where federal grants and contracts have been reported by the funding agencies and by the performing laboratories in the universities, firms and other private or semi-public institutions.

Some useful indications of recent levels of construction-related R&D funding and performance can be determined from the report, for example:

Funding

Department of Regional and Industrial Expansion	-	over $22 million
Canadian Electrical Association	-	$12 million

Hydro-Québec	- $46 million
(In-house: $26 million; contracts to universities: $10 million; contracts to firms, etc.: $10 million)	
NSERC (university grants)	- $4 million

Performance

DBR, NRCC	- $9.8 million
Ontario Research Foundation	- $5 million
Alberta Research Council	- $2.3 million
McGill University	- $2.5 million
University of Alberta	- $2 million
Concordia University	- $0.8 million
Universities of Toronto and Waterloo	- $0.4 million

(d) Rakhra[4]

Rakhra developed estimates for a time series, in current and constant dollars, for construction R&D in Canada between 1967 and 1976. He used mainly the Statistics Canada data available for government expenditures by departments and agencies, including those for university support and industry grants, the industrial R&D survey reports, and the annual reports on levels of construction activity. Based on this time series, Rakhra estimated that the national figure for intramural construction-related R&D expenditures for 1980 was $52 million in current dollars and $24 million in 1971 dollars.

Rakhra's main results are summarized in Tables 1 and 2. Table 1 indicates that between 1967 and 1976, construction-related R&D expenditures more than doubled in current dollars, but rose by only 22% in 1971 dollars. Table 2 shows that the federal share in construction-related R&D declined from 57% in 1967 to 48% in 1976, but industry's share increased to 36% from 24%. The percentage contributed by universities and provincial governments did not change significantly.

TABLE 1. Estimated Intramural Expenditures (in $ millions) for Construction-Related R&D in Canada by Sector

Year	Federal government	Industry	Universities	Provincial governments	Total current dollars	Total constant 1971 dollars
1967	10.5	4.4	2.8	0.7	18.4	21.5
1976	20.2	15.1	5.5	1.2	42.1	26.3

Source: Rakhra, A.S., "Construction research and development", Institute for Research in Construction, National Research Council of Canada, unpublished.

TABLE 2. Performance of Construction-Related R&D in Canada by Sector

Sector	Percentage of total	
	1967	1976
Federal government	57	48
Industry	24	36
Universities	15	13
Provincial governments	4	3
	100	100

Source: Rakhra, A.S.[4]

ANALYTICAL FRAMEWORK FOR CONSTRUCTION R&D

The key questions that should be answered in any survey of R&D expenditures are: How much? By whom? On what? National statistics answer the first two of these questions. Answering the third requires qualitative as well as quantitative input. In an environment of financial stringency and potential shortfalls in technical manpower, the need to get value for money becomes increasingly important. National statistics should, therefore, help to answer it.

For Canada, where the statistics presently available are not sufficient to provide proper answers to the first two questions, answers to the third cannot even be attempted. The first priority, therefore, is to improve significantly the collection and analysis of R&D statistics. But this should be done keeping in mind the need to answer the third question, and allowing for the exercise of good judgement with regard to the interpretation and usefulness of the data collected. The analytical framework suggested in this section tries to fit these requirements.

The framework is essentially a standard matrix. One part of it is the performer/source of funds relationship found in all analyses of national or sectoral R&D activities. The other two parts are less familiar. The first links performers with the principal fields of application, building and engineering, both separately and together. In this way, the percentage of total effort devoted to each of these fields is made clear. The second links performers with technical, socio-economic and other fields of application; for example, materials, structures, energy, equipment, etc., as shown in Table 3. This is the most sensitive part of the framework. To ask for too much detail will provoke resistance from respondents. To ask for too little will not be helpful.

The framework is intended for use at several levels of organization. For example, at the national level the sources and performers will usually be government, industry, non-profit institutions, universities and colleges, and foreign institutions. At the sectoral level, there will be government agencies, industry sectors, individual universities and non-profit institutions, etc.

An example of the application of the framework is shown in Figure 1, in which an imaginary set of statistics for a level of government has been

PERFORMER	SOURCES OF FUNDS ($ MILLIONS)						FIELD OF APPLICATION (PER CENT OF TOTAL ACTIVITY)			FIELD OF APPLICATION (SEE TABLE 3: ATTACHED)
FEDERAL AGENCY	TREASURY	INDUSTRY PROGRAM	HOUSING AUTHORITY	OTHER GOVT. LEVELS	PRIVATE SECTOR	FOREIGN & OTHER	BUILDING (A)	ENGINEERING (B)	BUILDING AND ENGINEERING (C)	
DEPT. OF PUBLIC WORKS	6	1	-	-	4	1	20	50	30	1,2,5,7,11,14,16
BUILDING RESEARCH LABORATORY	4	5	1	1	2	1	70	10	20	1,2,4,5,7,9,11, 13,14,16,18,20
HOUSING INDUSTRY	-	1	10	2	1	-	90	-	10	5,9,11,14,16,17, 18,19,20
DEPT. OF TRANSPORT	6	-	-	2	3	-	-	85	15	2,3,6,12,15,17, 18,19,20

NOTE: FIELD OF APPLICATION: A - APPLICATION TO BUILDING ONLY
B - APPLICATION TO ENGINEERING ONLY
C - APPLICATION TO BOTH BUILDING & ENGINEERING

FIGURE 1

ANALYTICAL FRAMEWORK FOR CONSTRUCTION R & D ACTIVITIES AT THE FEDERAL AGENCY LEVEL

TABLE 3. Suggested List of R&D Fields of Application
(The appropriate numbers are to be entered in the right-hand column of Figure 1.)

1. Materials
2. Structures - land-based
3. Structures - marine and ocean
4. Components and sub-assemblies
5. Energy production, conservation and use
6. Environment - exterior
7. Environment - interior
8. Equipment for the construction process
9. Heating, ventilating, air conditioning and refrigeration
10. Other equipment for functional use in buildings
11. Computers and systems
12. Transportation and other infrastructures (including pipelines)
13. Protection from smoke, fire, and other hazards
14. Rehabilitation, renovation, heritage conservation, etc.
15. Construction techniques, processes and productivity
16. Evaluation of performance, operation and use (including human/social aspects)
17. Costing, cost optimization, etc.
18. Economics, markets and financing
19. Management
20. Codes, standards and regulations
21. Other fields not included above

NOTE: Routine activities should not be included as R&D where they apply to testing, demonstration, inspection, commissioning, maintenance, and planning.

given. Attempts were made to apply this framework at the national level in Canada and at the federal agency level, but were abandoned because of the uncertain nature of some of the data. However, the authors believe that, given proper data, the framework will be a useful analytical tool.

CONCLUSION

A significant part of knowing what advice to follow in the field of construction research and development is knowing what has been done, by whom, and in which fields. This requires effort to gather statistical data on past activities.

Several attempts have been made to produce this kind of information for Canada, but none have been sufficiently accurate or authoritative. The situation has been complicated by the multiplicity of "actors" in the construction business and by the lack of pressure on the national statistical agency to do more than it has done.

This report has defined the problem, and suggested a possible solution and a method for organizing it. Hopefully, this will stimulate efforts to find more effective ways of data reporting and collecting and more useful analyses. However, these efforts will require that a single agency be given a leading role to play in this activity.

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