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An International Agenda for Research

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GLOBAL BUILDING MODEL IN THE NEXT MILLENNIUM CONVENTION 12-15 APRIL 1999

AN INTERNATIONAL AGENDA FOR RESEARCH

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ABSTRACT

A "global" agenda of needs of customers of the building and construction sector is emerging. To deliver this agenda will require new knowledge. Networks such as CIB, which provide integration of individual research efforts, are important for this delivery, and so is ensuring that new knowledge reaches those who can use it. There are mutual benefits for codes and standards bodies and for researchers from having building controls which embody new knowledge and encourage the application of innovation. Some studies have predicted enhanced national economic performance from improved efficiency of the building and construction sector, and the mutual benefits of this for the industry's customers, the researchers and the national economies are reviewed.

1. THE CIB NETWORK

No one organisation can regard itself as having a monopoly on knowledge. This was driven home to me recently when I was reviewing a report on the future of building and construction research by laboratories of major Japanese contractors (Okamoto and Pollington, 1998).

There are 22 laboratories listed there which are more than twice the size of our own at BRANZ - the Building Research Association of New Zealand. We have the largest turnover of any research organisation in New Zealand derived from providing science and technology services to the New Zealand building and construction sector - and the largest of those Japanese private sector laboratories is more than ten times our turnover.

Yet despite this relative minority in size we are in frequent dialogue with Japanese researchers, because even with that effort they do not hold the answers which we do to some problems which arise from the mix of climate, geography, geology, materials availability and social customs that is uniquely New Zealand. I do not pretend that we are alone in participating in such discussions. Every nation's building and construction sector must continually identify ideas from other countries and integrate them with ideas which arise due to their own national characteristics. There is no doubt that some nations are ahead of others in different fields; for example design against earthquakes is probably better advanced in New Zealand, Japan or California than it is in Australia or most of Western Europe; and computer rendering techniques for building information are very advanced in Finland compared with many other parts of the world. But every nation can learn from any other.

And that is why I am such an ardent advocate of networks such as CIB - the International Council for Research and Innovation in Building and Construction, of which I am proud to be President at present. CIB has over 500 members in 59 countries. Many of those members are organisations such as my own, or CSIRO Division of Building, Construction and Engineering, where the single member brings many actual participants in activities. Thus, we have a network of over 5000 experts involved in the 56 CIB Working Commissions and Task Groups.

These groups, each with a leading researcher as Coordinator, address issues ranging from fire (the longest-standing Working Commission), through structural engineering, indoor environmental issues, organisation and management of work forces, sustainability, economics and social issues. (The full range of these can be seen on the CIB Home Page on the world-wide web at http://www.cibworld.nl/.)

The pattern of work is evolving - hence in the period 1995-8 CIB established 18 new groups, and closed down 11 groups for reasons of completion of the task they had set themselves, or an inability to get a significant international mix of participants.

In addition to these pools of experts producing their state-of-the-art reviews and reports on joint projects, CIB uses some overarching themes that run through our work. Thus the three-yearly World Building Congress in Gavle, Sweden last year had as a theme "Construction and the Environment". The theme for the next Congress, in Wellington, New Zealand, in April 2001, is related to "performance", considering performance specification, measurement of performance of the built environment in practice, performance of the industry which is creating the built environment, and innovations to aid performance.

There are two commonly asked questions by some who work in the industry outside the research organisations:

- Why do we need more innovations and new information?
- Don't we already have a problem with applying all the information which we have?

I'd like to examine these questions one by one.

2. WHY DO WE NEED MORE INNOVATIONS AND NEW INFORMATION?

The answer, as it is in many things today, is "money". Delivery of a new construction project for less cost is a benefit to the direct customer (and to national economies, as I shall discuss later), and the world orientation is toward seeking customer satisfaction.

The basis of a global agenda for building and construction research is surely shown in Table 1. There seems an international consensus among customers of the building and construction sector regarding the extent of the improvements required for each issue. It is based on a list generated in the USA (Wright et al, 1995), but it has close relationships to those that have been generated subsequently in Europe (Tupamaki, 1997) and Australia (New South Wales Government, 1997).

I believe we can interpret this as a *de facto* globalisation of targets being set by customers of the building and construction sector. The most generous estimates I have seen are that 10% of construction work is put in place by companies working across a national border, which hardly suggests that globalisation is the rule for the "realisation" phase of the industry. But there is little doubt that multinational customers are carrying demands between countries, and that the market for small building components - water taps, hinges and catches for windows, etc - is now effectively globalised.

Table 1. A research agenda for the building and construction sector

Target	Comment	Better industry structure	New knowledge	Know the customer
50% reduction in delivery time	*Time is money both for customers - especially if normal operations have had to be disrupted to allow the construction process to take place, or if funds have to be borrowed for a project to start - and for the industry.*	✓	✓	✓
Zero defects	*This was not in the USA list, but is a desirable goal. Like several other targets it may be achieved as part of achieving others. It will rely on better use of existing information, and timely recognition of the need for, and delivery of, new knowledge.*	✓	✓	✓
50% reduction in operation, maintenance and energy costs.	*Energy efficiency is squarely on the political agenda, and the industry has a choice of setting a target of its own, or of having one set for it by others.*	✓	✓	✓
50% more durability and flexibility	*That is, capabilities of the building/structure to continue (with appropriate maintenance) its initial performance for a long period, and to adapt to address changes in users needs, because facilities usually last for many decades.*		✓	✓
50% reduction in construction work illnesses and injuries.	*In many countries, including USA and New Zealand, there are a disproportionate number of deaths of construction workers at work.*	✓	✓	
50% less waste and pollution	*Construction waste is estimated in USA at 20-30% of volume of landfills.*	✓	✓	
30 % increase in building user productivity and comfort.	*The annual salary costs of the occupants of a commercial or institutional building are comparable to the capital cost of the building. Improvement in productivity of staff is the most important performance characteristic for most facilities.*		✓	✓
50% fewer occupant related illnesses and injuries	*This will contribute to the productivity target; but is also a target in its own right, with sick building syndrome, fire and falls as specific focus points in USA.*		✓	✓

To make progress on every issue in Table 1, it is suggested that new knowledge is needed. It may not be the types of knowledge that we have been accustomed to collecting in our research, and indeed the landscape of research is shifting from a dominant emphasis on physical sciences and engineering to a broader view of investigating how the technology is best used, and its different effects when used in different settings (Duncan, 1997, 1998). Our ability, all around the world, to obtain improvements in site safety has not matched our ability to build stronger, taller buildings; though again, there are some countries which can be used as exemplars for others (Duff et al., 1997)

Table 1 also highlights the drive for "customer satisfaction" as a driver for commercial activity. For the developed nations, we are mostly past the stage of needing "cheap shelter" (Seaden, 1996), and renovation/replacement rather than "greenfield building" is becoming a dominant industry workload. In every nation, even in those nations where poverty and lack of adequate shelter are still problems, the delivery of the optimum built environment will be aided by a clearer understanding than we have seen in the past of the way people want to live in buildings. How people want to live in and use the built environment will have a major influence on the operating costs that will arise, and the extent of flexibility that emerges. The concept of "open building", to assist flexibility, has a community of interest in a few countries (Kendall, 1998) and the lessons which can be learned from this may have an interesting impact in the early 21st century.

There have been a plethora of activities over the last decade regarding questions of the best shape for industry re-organisation - the third key facet of attaining the goals in Table 1. The most recent such list, the Egan Report (Egan, 1998) in the UK, has set some targets for improvement in its industry performance which are shown in Table 2, and proposes use of "demonstration projects". The sense of these targets is similar to those in Table 1. Long before the Egan report, examples came from Singapore (Construction Industry Development Board, 1989) and Australia (Industry Development Working Group, 1991) - the latter of which was proposing demonstration projects even then. We are seeing "benchmarking" activities increasingly being suggested for application in this industry. These demonstration projects are one example, and the recent publicity given to applying the regulation schemes for plumbers in Australia to "cowboy" builders in UK is another

Table 2: Goals set for the UK construction sector in the Egan Report.

	Indicator	**Improvement per year**
Capital cost	All costs excluding land and finance	Reduce by 10%
Construction time	Time from client approval to practical completion	Reduce by 10%
Predictability	Number of projects completed on time within budget	Increase by 20%
Defects	Reduction in number of defects at handover	Reduce by 20%
Accidents	Reduction in number of reportable accidents	Reduce by 20%
Productivity	Value added per head	Increase by 10%

Perhaps a more worrying point is that these are being driven by Government-appointed bodies, rather than by the industry itself. Yet there could be very sound reasons why Governments adopt this line. I am aware of three studies in Australia and New Zealand which show that there would be a positive impact on virtually every other economic sector in these economies from an improvement in the efficiency of the building and construction sector. Efficiency is defined here as "delivery of increased outputs at a given level of capital and labour inputs", thus leading to construction cost and price reductions.

The first of these was reported for Australia by Stoeckel and Quirke (1992). Some relevant data from that study are shown in Table 3. The authors drew attention to the very large impact of the sector on the productivity of the mining sector. This was attributed to the very large fraction of the input costs to the mining sector which the construction sector provides. The table refers to increases in "real gross output". This means that if the same amount of resources were applied in the industry sector in question, when the step improvement of efficiency in the construction sector had been attained, the amount of product from that sector would increase by the percentage shown. I am unaware of any subsequent reports on the Australian economy of this type, even though the Australian economy may be rather different in shape now.

Table 3: Effect of a 10% efficiency improvement in the Australian construction industry.

Real gross domestic product (GDP)	+2.5%
Employment	+0.1%

Real gross output in all other sectors rise: for example:

Mining	+8.5%
Rail transport	+3.4%
Telecom	+1.9%
Water	+1.8%
Electricity	+1.8%
Transport and storage	+1.7%
Insurance	+1.7%
Restaurants	+1.5%
Road transport	+1.2%
Agriculture	+0.5%

The other two of these studies looked at models of the New Zealand economy in respectively 1986-7 (Philpott and Nana, 1993) and 1995-6 (Poot et al., 1998). BRANZ commissioned the report on the economy in 1986-7 - then the latest modelling available - to assess what the effects in New Zealand would be in similar terms to those used by Stoeckel and Quirke. We expected that the results would be a little different, because though both economies are dependent on export the relative weighting of agricultural-based exports is much higher in New Zealand. The national econometric models used in each country are slightly different, so exact comparability of the two countries was not possible. But in qualitative terms the answers are still the same.

It was known that there was a quite different industry workload pattern in New Zealand by the mid-1990s, and so the effect of this was investigated using the reference year 1995-6 in a further study last year (Table 4). There is a positive impact on the economy in each year - albeit at different levels, as shown in Table 5. Poot et al. (1998) concluded from their study that efficiency gains in building and construction have a relatively large impact on the New Zealand economy, and this finding is robust to a change in reference year.

Table 4: Comparisons of building and construction sub-sector contributions to New Zealand GDP in 1986-7 and 1995-6.

As % of total construction	1986-7	1995-6
Residential building	37	51
Non-residential building	37	29
"Other construction" and land development	26	20
Total construction value added as % of factor cost GDP	5.1	4.3

Table 5: Effect of a 10% efficiency improvement in the New Zealand building and construction industry in the two reference years on some national economic indicators.

	1986-7	1995-6
Gross domestic product (GDP)	+1.3	+1.2%
Labour employed	+0.3	+0.2%
Export volumes	+1.6	+1.5%
Import volumes	+0.8	+0.7%
Consumer prices	-0.5	-1.7%

Real gross output in all other sectors rise: for example:

Basic metals	+2.6%	+3.1%
Fabricated metals and machinery	+1.8%	+1.6%
Wood and wood products	+1.7%	+1.6%
Non-metallic minerals	+1.8%	+1.5%
Transport and storage	+1.7%	+1.4%
Mining and quarrying	+1.8%	+1.3%
Chemicals, plastics, etc	+1.6%	+1.2%
Finance	+1.5%	+1.2%
Communications	+1.5%	+1.1%
Electricity gas and water	+1.2%	+1%
Trade, restaurant and hotels	+1.2%	+1%
Agriculture	+1.0%	+0.8%

What are some of the items that would lead to this enhanced efficiency, and hence to the economic gain to the nation? As long ago as 1989 there were some suggestions (Construction Industry Development Board, 1989) of items which would enhance cost competitiveness:

- more extensive use of standardised and prefabricated building components
- less wastage of materials on site
- better scheduling of operations on site.

Seaden (1996), in discussing the cost benefits of research in the sector, points to a range of innovations that have revolutionised the way the industry (and society) work - for instance, the lifts which enable high-rise buildings to be viable work and living spaces. The ability to move information electronically provides major opportunities to prepare documents once and archive them for use many times, lessening the need for re-preparation, or for errors in transcription. Each of us, in our own local industries will know how new innovations and efficiencies could be achieved. Table 1 might provide us with an ongoing set of goals as a clear driving force, too.

A note in closing regarding these economic impact studies. I have heard a few reports of criticism in some circles of the economic modelling which underlies such pronouncements, though I have not been able to locate specific references. I have four comments on this:

- Criticism of economic models is easy, and different sector groups (including the construction sector) can inevitably derive models which promote their own cause or denigrate the causes of others. In each of these instances, models were used by economists independent of the construction sector, who had no vested interest in the results coming out in the way they did.
- Why would these professional economists expose themselves to criticism by using models they thought were incapable of delivering valid results?
- If the models are so wrong, why have we not seen better ones proposed, which will have universal support and for which all sector impacts can be assessed impartially?
- The qualitative results are intuitively sensible (even if the quantification of the directions would not be possible by intuition). That is an important test in every investigative exercise.

3. DON'T WE ALREADY HAVE A PROBLEM WITH APPLYING ALL THE INFORMATION WHICH WE HAVE?

The answer to this is complex, but a qualified "yes". No matter which country one is in, there is fragmentation of the industry, and so potential communication difficulties in taking all those working in the industry to new levels of understanding of knowledge. Just as we cannot make a significant impact on the average energy efficiency of the housing stock without addressing the refurbishment of the existing houses, many of which are very elderly, so we cannot raise the knowledge and performance levels of the workforce without retraining those already working in the industry. There are therefore issues both of rendering the information useable by those who need it, and then making sure that they know of its existence and apply it.

But because of the economic driver for more information and innovation to be produced, we are going to have to find innovative ways of managing the process, rather than simply throwing up our hands and trying to stem the tide of knowledge in the fashion attributed to Canute.

The building controls regime is a key method for dealing with these problems, by defining the minimum levels of performance which are to be attained - whether in prescriptive or performance terms. To achieve customer satisfaction, there is often a need to exceed these minima, and this option seems inadequately understood both by customers, in writing their specifications, and by the industry in its advice to potential customers on delivering product which is fit for its intended purpose.

Aided by the availability of electronic communication tools, there is no reason now why exact solutions to problems cannot be delivered right to the worker on site to allow the attainment of the specified requirement, in a format which is tailored to the level of understanding of the particular user. This is an area in which the CIB commission on Information Technology in Construction has been very active, and the report of their latest conference (Bjork and Jagbeck, 1998), while still drawing its examples mostly from the "design" rather than "realisation" phase, talks about how we can do this better. The advantage of work on issues such as "virtual reality" (and similar project modelling like this) emanating from within CIB is that the interdisciplinary approach of those who know the requirements from codes and standards, those who know the computer rendering techniques and those who are bringing the building and construction technology which it is intended to convey can be achieved from within the ranks of the single organisation.

I have never yet met a researcher in building and construction who is not passionate about having his or her work applied by others so that something new emerges which is "better", however that may be defined. It could be that a new product is developed or a new process is implemented which means there is a cheaper or more reliable means of attaining performance; it could be that it is a new way of simulating performance in service, or of analysing that performance.

The building control system is a fine answer to these desires of the researcher. Once the researcher has demonstrated to the satisfaction of the person(s) responsible for creating the control, and the new knowledge is embodied, those charged with supervising the controls are automatically enlisted in explaining the new knowledge to those who must use it in individual buildings. But this builds in a "reality check" for the researchers too; it ensures that the work which they are doing is attainable in practice, or it will not be incorporated and implemented. We can see a win-win here for the researchers and for the industry, by ensuring that the process of introduction of new ideas is also keeping the researchers in touch with real-world issues.

Researchers, then, have a strong vested interest in working with Standards organisations and with building control agencies to ensure that innovation and new knowledge are reflected in building control documents as they emerge, and there is, as discussed above, a strong national economic gain by ensuring that these documents engender the most efficient building and construction sector possible. It is unfortunate then that in many countries it seems difficult for researchers to get the funding to participate fully in the processes for setting building controls.

4. INTERNATIONAL PERFORMANCE CODE DEVELOPMENT

International trade is an issue of increasingly close inter-governmental scrutiny, and the issues involved in codes and standards for building and construction can be designed to assist or hamper international trade in the construction sector. The activities in the APEC region to create performance codes for loadings and structural design, housing and timber products (Leicester, 1997; Walker, 1997), coupled with the work on the corresponding ISO Technical Committees, are examples which have the capacity to yield greater scope for easy movement between countries of ideas related to the building and construction sector.

CIB Working Commission W60 on the Performance Concept in Building and Construction was formed almost 30 years ago to help with understanding the underlying issues. We should be honest and admit that researchers are not just being altruistic in desiring the spread of performance-based codes, even though it does provide an easier avenue for incorporation of research findings and easier acceptance of innovative thinking than do prescriptive codes. "Performance basis" is a comfortable notion for scientists and engineers, who are constantly needing to work on fact-based issues. The introduction of performance codes forces the realisation that there is so much about the performance of prescribed items which we do not actually understand, so creating a need for more research, if the introduction of innovative ways of thinking about issues, and solving design needs, is to be facilitated.

Despite these long-term efforts of the W60 participants, and those in the matching groups in ISO, RILEM and ASTM, and in other CIB Commissions such as W80 on Service Life Prediction of Building Materials (Sjostrom, 1996), there clearly remains a lot of unresolved ground. There have been regular conferences between participants in these groups, stretching back to 1972 (Foster, 1972). An important task for the research community is to ensure that this fragmentation of interested bodies becomes a force for the good, by bringing the different interests to a synergistic result, rather than fostering duplication of effort and splintering of implementation.

The work by CIB Task Group 11 (Oleszkiewicz, 1997) compared the approaches of a number of countries toward performance specification, and identified that there are many gaps in understanding even this generic area, let alone the correct specification levels. We have recently formed a new group (Task Group 37) to take this further, with the initial remit to produce a further guidance document outlining the issues, problems and solutions that have been useful in achieving a successful implementation of performance based building regulatory systems. We expect that it will work closely with bodies such as the Inter-jurisdictional Regulatory Collaboration Committee (1998) in these tasks.

CIB sees the international understanding of these issues as crucial, and would be pleased to work in with the APEC activities, and also those which the European Union is fostering as it moves toward alignment of the trading conditions for the building and construction sector across its member states or any other international activities. We are examining now the ability of CIB to compile a compendium of validated models of building performance, and a report on the economic benefits of using the performance approach to specification and control of building and construction projects, over the next two years. We hope that the Congress in Wellington in 2001 will be a key reporting point for bringing together the recent achievements and discussing them with the user community.

5. CONCLUSION

I have tried to draw here a picture of the impact that the research community can have in this pursuit of a Global Building Model for the Next Millennium. I have drawn examples from the work programme of CIB because I am familiar with it, and because I believe that participation in networks such as CIB is an important means of maximising returns on research investment.

I hope the messages that the paper will leave are:

- there are well-established networks that assist the production of new knowledge in the building and construction sector
- there is a *de facto* global set of drivers for improvement in the product the sector delivers, which forms the basis for a global research agenda
- generation of the appropriate new knowledge to achieve items on this agenda will bring positive economic benefits to nations
- application through codes and standards is a powerful tool for technology transfer in this sector
- researchers want to assist the application of performance-based codes systems.

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