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CONSTRUCTION INDUSTRY CHARACTERISTICS AND THE IMPLICATIONS FOR RESEARCH: A HONG KONG PERSPECTIVE

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ABSTRACT
The paper gives a brief overview of the results of the recent analysis conducted by Hong Kong's Construction Industry Review Committee (CIRC) and alludes to a number of similar exercises conducted in other countries. The importance of the role for the research community is identified and in particular the need for researchers and industry to work together. In doing so, academics should be involved in field experiments, i.e. using industry as the laboratory, much more than we usually do.

KEYWORDS
Construction Industry Change, Innovation Culture, Industry Based Research

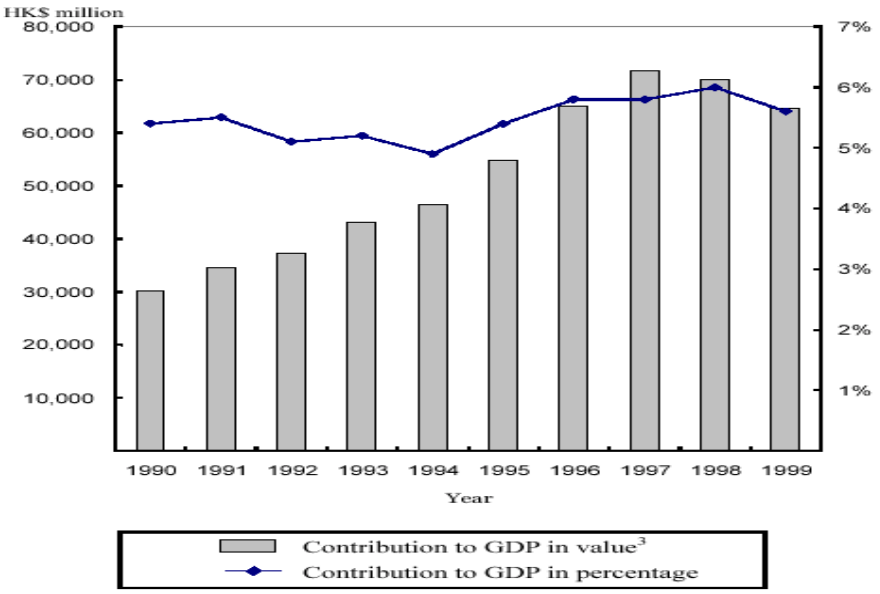
1. INTRODUCTION

Hong Kong is an interesting place from the point of view of construction professionals. Over 7 million people live in a rugged and mountainous area only about the size of the English Lake District, a small corner of the northwest of England. Some land has been reclaimed from the sea but most of the 7 million live and work in closely spaced reinforced concrete multistory buildings some of them apparently precariously perched halfway up the mountain sides. In peak periods the amount of concrete consumed per head per annum, approaches $1.5m^3$, which is 2 or 3 times the consumption typical elsewhere, except for the case of Japan. Construction activity is also inevitably so concentrated geographically, that it is an ever present part and parcel of life for just about everyone in Hong Kong. The standard joke is that "Hong Kong will be nice when it's finished". The author lives at the tip of the Kowloon Peninsula and can vouch for the fact that for a stretch of 700m at that location, construction activity has been taking place somewhere along that short length at all times during the last 14 years.

2. THE REPORT OF THE CONSTRUCTION INDUSTRY REVIEW COMMITTEE

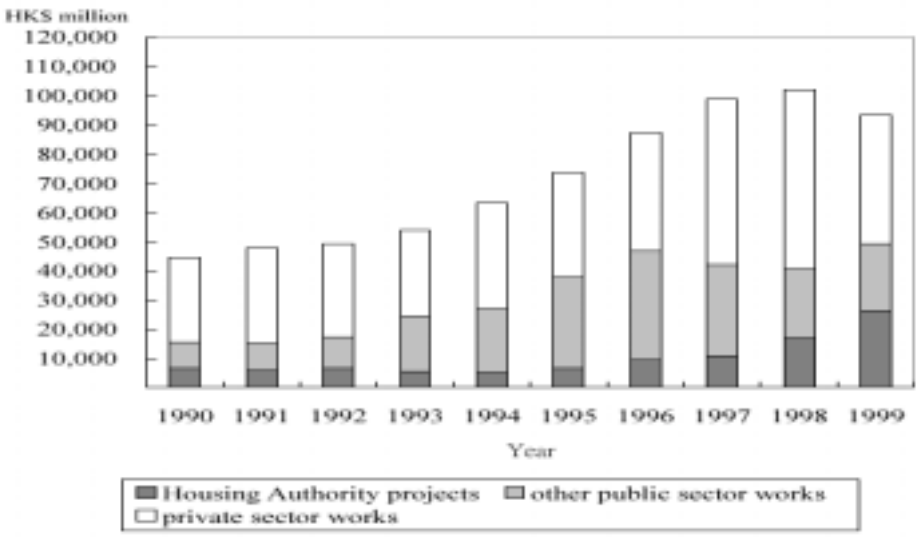
Fig. 1 (Hong Kong Government Statistics) shows the contribution of the construction industry to GDP since 1990. The 5 to 6% of GDP figure is not an unusual percentage for many countries in fact. The graph also illustrates the rapid economic growth rate of Hong Kong since 1990, a situation which had prevailed from well before then. The graph also shows the recent peaking due to the 1997 Asian financial crises which badly affected Hong Kong as elsewhere in the region.

Fig.2 (Hong Kong Government Statistics) shows that roughly half of construction activity is undertaken for public sector clients and half is private work.



Source : Census and Statistics Department

Figure 1: Contribution of the Construction Industry to GDP in Percentage and Value Terms (1990-1999)



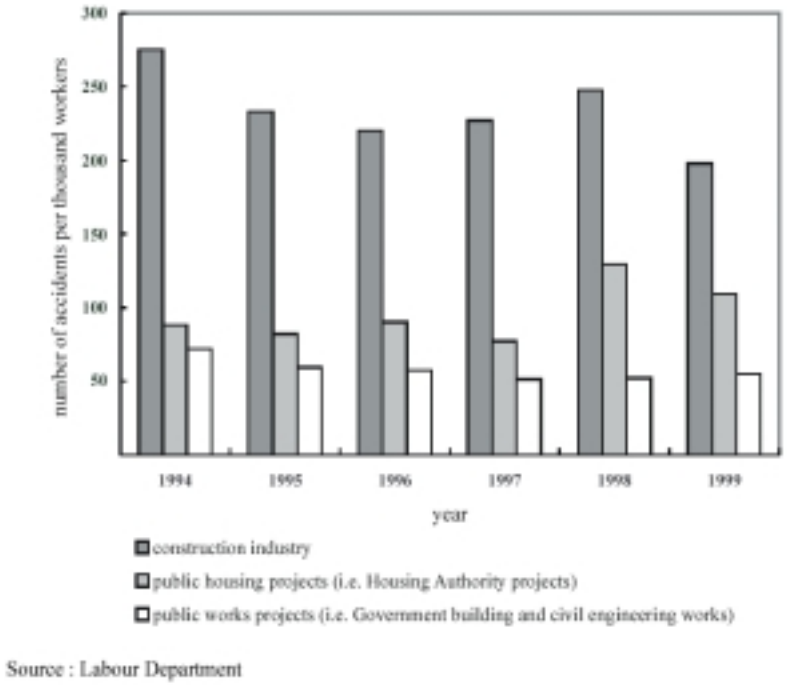
Note 1 : Other public sector works include construction projects undertaken by the Government of the Hong Kong Special Administrative Region, the Airport Authority, KCRC and MTRC.

Note 2 : Private sector works cover construction works undertaken by private sector developers, subvented organizations and the Hong Kong Housing Society.

Source : Census and Statistics Department

Figure 2: Gross Value of Construction Works Performed by Main Contractors at Construction Sites by Public and Private Sector (1990-1999)

Many spectacular and justly renowned successful construction projects have been completed in Hong Kong. These include, for example, major bridges, very tall buildings, road tunnels, an excellent underground railway system, and a state of the art International Airport. On the other hand, the safety record of the industry is poor (see Fig. 3) (Hong Kong Government Statistics) and there are many evidences of poor quality in the less prestigious projects and even some corrupt practices in relation to quality supervision. There is also concern that the system of subcontractor multi-layering is so complex in some situations, that main contractor control of the project is compromised. Finally there is evidence, see Fig. 4 (Walker and Chan, 1999) that total factor productivity in the Hong Kong construction industry has declined since 1993 following an average gain of 1.6% p.a. between 1972 and 1993.



Source : Labour Department

Figure 3: Site Accident Rates for the Construction Industry, Public Housing Projects and Public Works Projects in 1994 to 1999

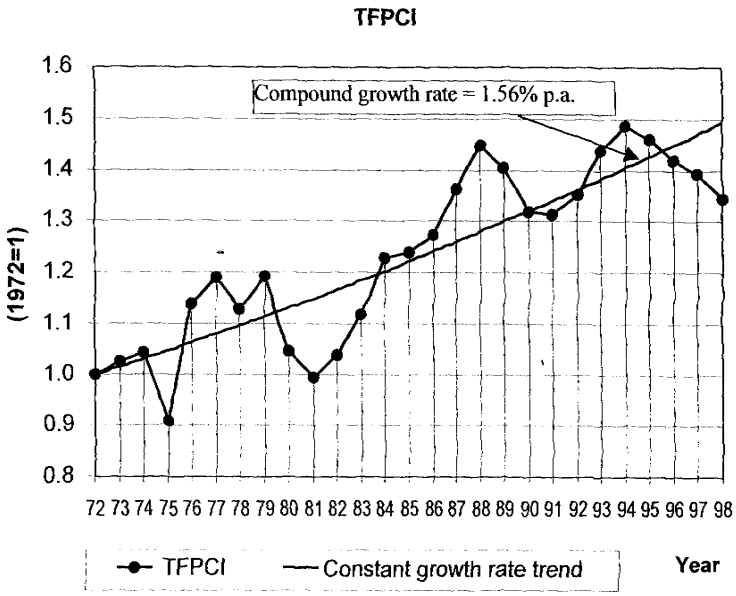


Figure 4: Total Factor Productivity in the Construction Industry (TFPCI)

For these reasons, and in keeping with enquiries made in some other countries, the Hong Kong government appointed a Construction Industry Review Committee early in the year 2000, which reported in January 2001 (Construction for Excellence, 2001). The various sub-committees involved a large number of people and the process was essentially one of self critical analysis by those in the industry and the brainstorming of steps which needed to be taken to change the culture.

The Committee identified the weaknesses and made a large number of detailed and broader recommendations:-

The weaknesses include:-

"Poor site safety record.
Unsatisfactory environmental performance.
Need for a more client focused approach.
Extensive use of traditional labour intensive construction methods.
An inadequately trained workforce.
Tendering to award contracts to the lowest bidders.
Short term attitude to business development.
Non value adding multi-layered subcontracting.
Declining productivity growth and high building cost.
Frequentation and adversarial culture within the industry."

The recommendations made are intended to :-

"Foster a quality culture.
Achieve value in the construction procurement process.
Nuture a professional workforce.
Create an efficient, innovative and productive industry.
Create a safe and environmentally responsible industry."

An implementation body is now being established with its own secretariat and is an organization "set up by the industry, for the industry" Government bodies, of course, are both key clients and also regulators, roles which must be kept separate. Government bodies are seen as a direct part of the "industry" in their client capacities. The CIRC committee sees the clients (both public and private) as the necessary key drivers in the implementation of change.

3. SOME OTHER NATIONAL REPORTS

The CIRC review in Hong Kong can be seen as part of an international trend. Studies of a broadly similar nature have been made in Singapore (Re-inventing Construction, 1999), the U.K. (Constructing the team, 1994; Rethinking Construction, 1998) and Australia (Building the Growth, 1999). The same applies to a report from Sweden (Flanagan et al. 2001) except that this latter report is particularly strong on the potential for technological innovation with good detailed background on the possibilities also provided. There are useful additional related reports from Singapore (Dulaimi and Ofori, 2001), the U.K. (Construction – A 2020 Vision, 1999) and Australia (Innovation in the Australian Building and Construction Industry, 2001), the latter two dealing with innovation in particular.

Improving the performance of a construction industry requires attention to a number of areas, as stated above. In one sense, 'innovation' is a word which might be used to describe any improvement, even, for example, new workforce training techniques and content, but for the rest of the paper it will be taken to refer to new technologies which have the potential for changing the way we do things in the industry, both in the technical sense and the organizational sense. By 'technical sense' is meant with respect to the technology of the final built product. By 'organisational sense' is the influence of new technologies on the construction procurement process.

The Hong Kong CIRC report and those of Singapore, U.K., Australia and Sweden all point out the undesirability of the adversarial culture in our fragmented industry which seems to be pervasive and would like to see changes towards a culture of partnership based on mutual trust and a shared feeling of all parties working as teams on projects towards the goal of high quality and value for money. Involving the constructors much earlier than is common in the conceptual and design stages is not unconnected with partnership goals. Neither of these cultural changes, which of course are no longer particularly new ideas, depend upon new technologies per se, though the improvements in e-based communications, which are still in the early stages, will undoubtedly make a big difference

to the timely information sharing between different parties thus rendering partnership approaches more viable. Even so, at the root of successful partnering there must exist a genuine attitude shift among the individuals involved. Without that, no amount of sophisticated information sharing technology will be of much help.

4. ASPECTS

Of special interest to the research community, is the recognition in the CIRC report of the need for the industry to be more innovative and the following specific recommendation, amongst others, is made to the new implementation body,

> "to identify priority areas in construction research and to promote better coordination between the local research community and industry in order to encourage innovation in local construction".

Construction industries everywhere are not famous for their enthusiasm for investing in research, but in Hong Kong, there is almost no tradition of industry involvement in research except to the extent that industry will sometimes respond positively to requests from the academic community for data and/or access to sites for observation purposes. The research agenda is very much driven by academics, usually using government funding made available for research in general, to all academic disciplines, and competed for amongst themselves by academics of all disciplines. There is, however, a new scheme, still small, whereby research students can be based for their studies in industry under joint university/industry supervision and funded by industry and government on a 50/50 basis.

The construction academic community in Hong Kong can be found in about 10 departments in 5 universities. These include Architecture, Civil & Structural Engineering, Building & Real Estate including Economics, and Building Services groups, many of whom also specialise in environmental fields and of course IT fields. The total number of research assistants, associates and Ph.D/M.Phil research students in all Hong Kong Universities is estimated at about 500 in the construction fields. Faculty staff leading and supervising this 500 is about 200. Much of the research undertaken in the Universities is intended to be relevant, of course, to the advance of the industry, but the programme would probably be better informed if the industry would be involved in the prioritizing process.

One sector of industry, however, the Housing Authority (HA), a significant part of the construction industry (Fig. 2 above) has made pro-active independent steps of its own (Construct for Excellence, 2001; Greener Housing for the Millennium, 2001) towards the environmental objectives of the CIRC report. It has also just created a small research fund (of about US$2.6 million) and intends soon to call for bids. Towards its environmental objectives, the HA has clear construction objectives, with target dates, which include the following:-

> "CFC + HCFC free thermal insulation materials to roofs.
> Reduce Energy consumption.
> Reduce noise complaints during demolition and piling.
> Design for protection from traffic noise.
> Use water saving fittings + reduce water wastage during construction.
> Reduce construction and demolition water.
> Reduce the use of non-sustainable timber.
> Explore ways to enhance environmental designs.
> Assess life cycle costs."

Those researchers of our industry who study the construction procurement processes, must work towards models and solutions which are both technically viable and attractive enough to practitioners, if implementation is to occur. As far as possible researchers must actually test out new proposed systems, say, because our academic ideas are not complete until they are tested by practice. Research aims to produce 'new knowledge and understanding', but this is of a very limited and poor value in the area of construction procurement research unless field experiments are also conducted.

The author remembers the very great interest with which the Critical Path Method was initially greeted in the early 1960s by many in the construction industry and the subsequent 'reality check' when field experiments (Anson and Clark, 1968) for example demonstrated that the technique could indeed be helpful, but the effort involved added considerably to the overhead costs, if the job was done properly. Much better and faster computers and user friendly

software has become commercially available since then however, also with a range of useful and usable outputs, and CPM based systems are now widely used as decision support tools with greater or lesser degrees of skill and commitment throughout the industry.

We see a broadly similar situation today with 3-D, 4-D graphics systems on construction sites – or at least the lack of such systems on typical sites in Hong Kong – even though high powered graphics capabilities with very realistic imaging have been around for many years now. Researchers have already constructed impressive software systems intended to improve the management of sites by adding the usual management planning and administrative support functions to a 3-D visualization capability. There is little doubt surely, that such software support, at the centre of each project management office will be universal at sometime in the future. Recent site testing, however, by our group at Hong Kong Polytechnic University/Tsinghua University of quite a complete 4-D system, and one which the academics who developed it are quite proud of, has revealed just how far away it is from really being implementatable. Just as for CPM in the old days, the overhead effort is simply too much. It's not user friendly enough, the volume of data handling on a real job slows down even modern equipment unacceptably, the inputting of raw data and updating data needs to be materially machine assisted.

Illustrative also of the gap between what we academics do and what practitioners want is the fact that few researchers seem to have been concerned with how to evaluate how good a site layout is, in any realistic way. This means it is not possible to optimize a site layout, however easy it is to propose alternatives via our 4-D/3-D modeling wizardry. Our own field experiments, however, of a manual procedure have shown that detailed evaluation of the materials handling effort can be made with arduous attention to detail and much time, rather as was also the case with CPM all those years ago. As then, the overhead is too great and site evaluation processes needs computer assistance too and linking to 3-D modeling (Li and Li, 2001).

Such research field work proves fascinating and rewarding, however, and sustains the writer's belief that construction procurement research must involve field experiments as an integral part of the job whenever this is possible. Theoretical concepts and hypotheses can no more neglect the industry itself as a test bed than a materials researcher can avoid doing laboratory experiments. (When field experiments are not possible simulation experiments of proposed models would sometimes be a useful substitute.) Of course, it is much easier for a materials researcher to set up laboratory experiments than it is for construction process researchers to set up field experiments.

Conversely, however, we have stumbled across a situation, which demonstrates how industry can miss out on a readily applicable long understood academic techniques. Ready Mixed Concrete is big business in Hong Kong and quite sophisticated and efficient. The average plant is large by world standards – operating 25 truckmixers and on any particular day there might be 30 customer sites, between 1 km and 10 km distant from the plant (Anson et al.). It looks like an ideal case for the application of Monte Carlo Simulation (and so it proves to be) in order to study the behaviour of the one plant – multi site system, as demand for concrete deliveries varies, say, and the resource provision applied to meet those demands is varied too. By making a considerable research effort (8 man months of detailed observation of real operations) it proved possible to construct a simulation model which takes only 1 min to simulate a day's operations for one plant, a model which has been validated for Hong Kong conditions to the industry's satisfaction. (not yet published) One application is to gain a better understanding of system behaviour and how to best optimize site service levels, another is to study how to use the simulation system, since a run takes one minute only, as a scheduling decision aid for daily operations. One company is working with us on this. Some might take the view that this is pure application research and the academic interest lies only in the simulation concept and the intellectual interest involved in constructing simulation enabling models. To the writer, however, operations research, which construction process research essentially is, cannot be separated from the world of human operated systems and as stated above the greatest research satisfaction and greatest value comes from 'advancing knowledge and understanding' of what works at the practitioner level. If there is any 'message' in this paper for the reader to digest, that would be it. We researchers need to close the gap between what we like doing and what the industry needs doing. If more academics take this view, surely practical progress would be that little bit faster, and the academic/university research divide, which is wide in Hong Kong, less so but still wide in the U.K., and perhaps less noticeable still in the U.S. (anecdotal evidence and the existence of a body such as the CII) would become narrower.

Returning to the technological advances we can hope to see, it is IT which will speed up the construction procurement processes and enhance its quality by increasingly removing misunderstandings and mistakes.

Inconsistencies in the source information held by all parties to a project should be eliminated. Supply of materials and components and labour should all benefit from the improved coordination (e.g. real time tracking for materials) as a result of good communications. IT based tools will continue to improve and assist the day to day decision making and administrative processes, and probably alter the present structure of the organizations which come together to complete projects.

The technological advances which will enhance the quality of the finished built product itself as opposed to the construction process and those which improve the physical part of the construction process, i.e. construction technologies, will be the subject of many papers in the conference sessions.

In broad brush terms, however, we are likely to see technological developments in the following areas, borrowing heavily from refs. (Flanagan et al, 2001) and (Construction – A 2020 Vision, 1999).

Use of Robots (many tasks)
Smart Buildings (security, local environment control, energy conservation, vibration control)
New Materials (carbon tube nanotechnology, 'steel strength' paint, smart paint, smart concretes, carbon fibre usages, piezoelectrics)
Environmental (fuel cells, solar energy, sound cancelling)
Construction Technology (virtual reality, lasers for paint stripping, robots)

There is clearly an enormous range of research opportunities open to us. Really we are spoilt for choice and the range of options seems to be getting ever wider. The hard thing may be to know what topic area to go into and the challenge for the Industry, in any particular place like Hong Kong (clearly it is too small to do everything) is to try and pick the areas most likely to help Hong Kong people.

5. CONCULDING REMARK

Hong Kong has a totally open construction market and many big overseas contractors bid successfully for work in Hong Kong. Many indeed, maintain an office in Hong Kong. The Hong Kong indigenous contractors, usually small in scale, often form joint ventures with overseas companies in relation to major projects. Since the major design consultants with the bigger offices in Hong Kong are also international businesses it is very likely that new technologies will find their way into new Hong Kong buildings and Hong Kong procurement processes from all corners of the world and some are tempted to say that Hong Kong can save its money and let others do the research. Innovations nevertheless, will take place more quickly if the Hong Kong clients themselves, including the major government clients, are 'innovation informed' and then 'innovation pro-active'. The CIRC report correctly recognized, therefore, that an innovation culture must exist within the Hong Kong construction industry and that one important step needs to be the pro-active involvement by industry with the academic research community, probably most effectively achieved via the big clients, as indeed the CIRC also recognized the key importance of clients as the drivers of change. The academic construction community in Hong Kong currently conducts research, much of which attempts to meet Hong Kong's needs, but, with a number of honourable isolated exceptions, there is little or no feedback from the industry as to whether the right problems are being tackled and certainly there seems very little impact on the industry to date. It is likely that much more effective research will be done if industry/university research partnerships could be formed.

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