TWO CASES of INNOVATION in the HONG KONG CONSTRUCTION INDUSTRY

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INTRODUCTION

Past Innovation in General

Innovation in construction is always an ongoing process. We have only to compare construction today with construction say 50 years ago, to appreciate what enormous changes have occurred. Even routine structural concrete, for instance, is much stronger, is easier to work with , sets more quickly and its quality on delivery is much less variable. Many new techniques and materials have appeared and construction plant has developed both in power and versatility .There has been a steady trend towards more and more offsite fabrication for structural and mechanical elements .

Industry organizes itself in new ways too. Various contract forms and methods of cooperation between parties have developed: there is more use of subcontracting; management principles are applied more professionally : thanks to the computer much better management information and design tools exist , introducing enormous changes in the way things get done.

These improvements have occurred because researchers, industry innovators and plant manufacturers have steadily pushed the boundaries forward.

Current and Future Innovation in Hong Kong

We now seem to have reached the stage where INNOVATION itself is seen almost as a <u>distinct activity in its own right.</u> Innovation is to be no longer left only to initiative and opportunity but the community seems to expects it to be consciously achieved by an Industry acting collectively.

The HK Government established a Construction Industry Review Committee (CIRC) which published its report "Construct for Excellence ", in 2001. That report contains 109 recommendations for advancing the Hong Kong construction industry. <u>In particular,</u> the report specifically charges the industry to collectively develop a **culture of innovation** , to deliberately concentrate on and foster innovation both in technology and in processes.

Innovative ideas and actions are being promoted on a variety of fronts, movements in the direction of sustainable development featuring particularly large for example. Industry, Academia, and Government Depts. have responded well to the CIRC report and the climate at present is one which welcomes innovative ideas.

Following the CIRC report, a Provisional Construction Industry Coordination Board (PCICB) was established to act as a conduit between Government and Industry and to implement the CIRC recommendations. Recently, on 1st February 2007, the Construction Industry Council (CIC) was established as a statutory body to replace the PCICB. Government departments in the meantime have been proactive in encouraging 'greener buildings' and in increasingly allowing, for example, a performance based approach to design. A worker registration scheme is now in place to improve worker quality. Formal assessment of the standards being achieved by a particular building is encouraged, the use of the 'instrument' HK- BEAM (Building Environmental Assessment Method) being prominent, and many recommended environmental target standards have been issued by Government. Such assessments and target recommendations , however , remain only voluntary for the private sector. The HK government , as is traditional, so far still likes to avoid compulsion except in matters of safety and health.

Interesting developments arising from the new climate in HK are the formation of CII-HK and the increasing use of quite large teams of academics pooling their different types of expertise in studying specific issues of importance to the community. CII is an association of industry firms and other bodies who contribute annual sums used to fund research . CII puts out research briefs and grants are awarded on a competitive basis. The chosen research ' contractor' and a CII task force formed for each project then coordinate the work. University teams are frequently bidders for CII contracts , and not only for CII contracts . University staff usually know what is going on at the cutting edge of their disciplines anywhere in the world, are skilled in investigative work and reporting and can assemble for debate much relevant information and discussion of the effects of various action scenarios. What to do about the problem of over 10000 privately owned inadequately maintained older multi storey residential buildings was one such study, for example. The academic research team included engineers, social scientists, economists, real estate specialists and law specialists.

Two Examples of Innovation in Hong Kong

Two examples of innovation chosen for this paper are as follows :

1) a cutting edge application of IT power to construction process visual simulation . A technological innovation also affecting working procedures.

2) the innovative formation of an association of construction businesses establishing a mechanism for sharing innovations experiences on actual projects and also of collecting performance measures actually achieved.. An innovation in Industry Culture.

INNOVATION 1. VIRTUAL PROTOTYPING VISUAL SIMULATION

An application of IT power to Construction planning via Visual Simulation.

Introduction

Construction lags manufacturing industry in productivity growth.. For example, in Japan labour productivity in manufacturing improved from 3,531 in 1990 to 5131 (Yen/Man/Hour) in 2004, while that for the construction industry dropped from 3,714 to 2,731 (JFCC 2006

In China, according to Ministry of Construction figures (MOC 2006) labour productivity in manufacturing improved 22% between 2003 and 2006 while construction improved only 0.5%

In the US , since 1964 , the manufacturing industry made steady annual improvements in productivity while the construction industry lost ground and continuously declined.

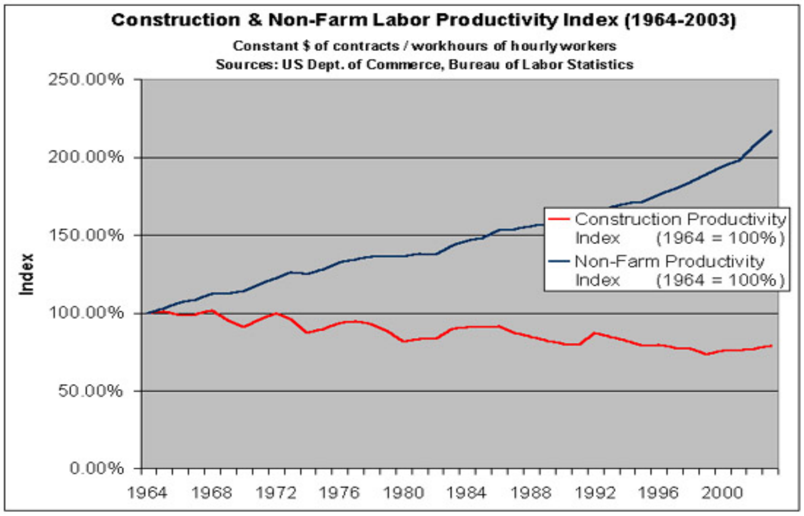

Figure 1: Productivity comparison between construction and manufacturing industries in USA

The reasons must be complex but in Manufacturing the existence of

1. a well defined production line, <u>at the same place</u>, on which products and parts handling processes and logistics occur repetitively over a lengthy period of time;
2. the ability to quantitavely predict risks and errors and
3. the ability to learn from mistakes and to avoid them on the next batch

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must be important factors. Importantly, also, such long term repeating conditions have justified the expensive investment in powerful visual software for simulating actual operations, based on three dimensional digital computer modelling of physical entities Such Virtual Prototyping (VP) technology has been extensively and successfully applied in the automobile and aerospace industries (Choi and Chan 2004).

The above three factors do not apply in Construction to any significant degree but the INNOVATION described here, currently being used in Hong Kong, does make use of visual simulation software first developed for the manufacturing industry and now further developed to suit construction processes by Professor Li in the Constructuion Virtual Prototyping Laboratory (CVPL) at the HK Polytechnic Univerity
.

With encouraging results, 7 contractors have used this VP system in Hong Kong in collaboration with the University over the last three years.

VP technology, through simulation in advance of construction, helps the construction industry overcome the second and third of the above weaknesses in construction. Since the construction industry also lacks an effective platform for the capture and re-use of the knowledge distilled from its design and production processes .because project teams are disbanded as soon as projects are completed , VP technology provides an effective platform for capturing and reusing knowledge.

As stated above the CVPL appliesVP technology to real construction in Hong Kong, each time "constructing the building many times" in the computer. All sorts of scenarios can be previewed and potential problems identified in advance. The simulation process visually displays such tasks as the production, transportation, handling and assembly of different construction components. Variables affecting the construction processes, such as site layout, plant locations, machinery performance parameters, quantities of resources, etc., are taken account of when testing the feasibility of proposed construction methods and sequences, and exploring possible solutions and improvements.

In a traditional planning process, planners construct a 3D mental model of the construction project by mentally integrating 2D drawings, CPM based schedules and other information. This is largely an experience based process. More experienced planners construct more comprehensive mental models and generate better construction plans than juniors. The VP technology reduces the need for mental integration and, especially valuable, brings all project participants to a closer level of understanding as to planned activities greatly facilitating effective communication. That project participants can thus evaluate different construction methods and identify possible risks and problems is another key practical benefit.

The Content of a VP Model and its Use in the Planning Process on Site

Project planners must first establish for testing the construction strategy , construction methods and assembly sequences, to allocate the resources required and ultimately to provide daily work instructions for field crews. Fig. 2 outlines the major planning stages and where the VP models on the right are utilised

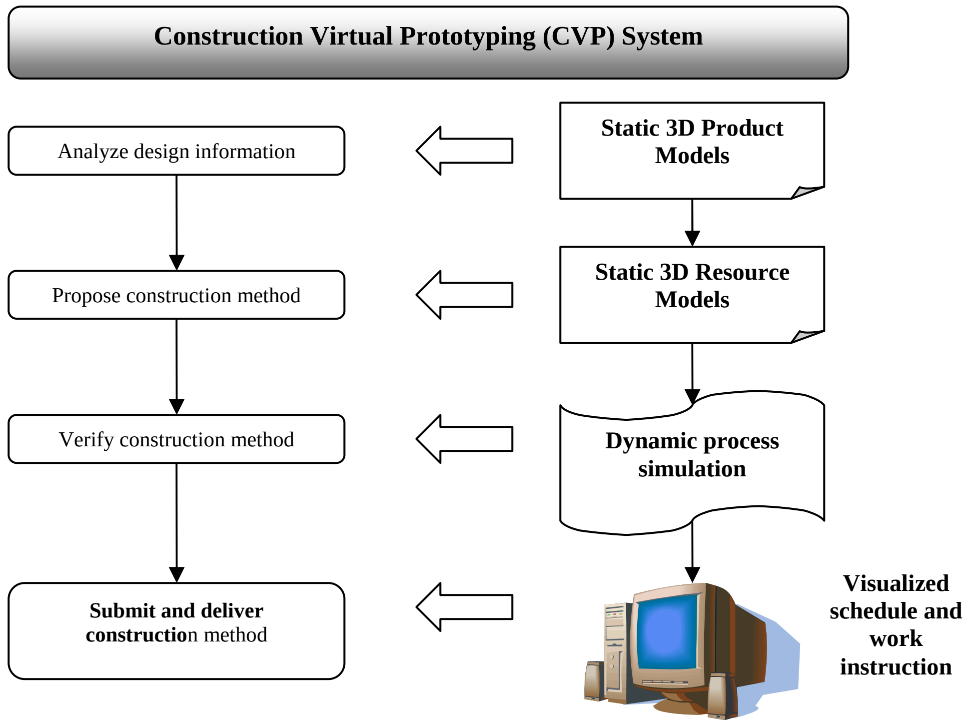

Fig. 2. The process of VP supported construction planning

The Static 3-D Product Model to be constructed is a digital representation of the final building , or 'product', under production.. Constructing these models reveals design errors as the model is entered into the computer, as an assembly of the many components involved. The site plan is also entered at this stage. The latter is needed for planning the allocation of storage space, space for construction operations and site circulation

The Static Resource Models are digital icon representations of plant items and icons for'temporary' items such as equipment excavations and formwork . Construction process sequence information is also included in this model category

The Dynamic Simulation Model accesses the data in the first two models according to a supplied work schedule, to display the construction progress as time is advanced., so-called 4D modeling. Operational sequences are digitally developed and their durations estimated based on plant performance data and available working space.

Since 'a picture is worth more than a thousand words ' communication of intentions to all parties to the contract ,including clients and subcontractors , at levels of scale appropriate to the recipients concerned is both easy and effective, and self consistent to all since everthing comes from the one data base.CVPL experience on the real projects is that the above process does work usefully on site.
Full information for model construction is not always available in the early stages and the content and level of VP model detail varies at different stages to fit management needs.

During the preconstruction stage, a site wide macro planning process involves reviewing potentially suitable construction methods and timings the resources required and plans how site space is to be utilized.. During the construction stage, a micro planning process develops detailed schedules for specific construction operations.

For a full description of the above necessarily brief outline see the paper by Huang et al (2007)

Case Study ---The HO TUNG LAU Project—The Models Involved

This section of the paper relates to an actually constructed project to build a Deck Structure over a railway line. Over about one year the work had to be carried out in short 5 hour bursts and the site cleared and handed back to the railway company each time and strictly on time.. The structure included composite columns, 285T trusses, 100T girders and precast T-beams placed across the girders. The site was restricted and damage had to be avoided to overhead train power lines, their supporting portal frames and a footbridge.

Model content is outlined below. The data listed were entered by the project team to create digital models. A process which occupied about 3 man months.

3D Product Model (after review of drawings)
Individual models for the columns, girders, trusses and precast beams
Model of full assembly of all components (the structure final form)
Component weights, volumes, numbers for analysis purposes
Site model including levels, boundary, adjacent buildings, site entrance, site road and access exclusion zones around permanent railway features.

3D Resource Model (after consideration of possible equipment alternatives)
Construction equipment rough representations for mobile crane, mobile gantry and launching girder. Fig. 3 for the launching girder (bottom left)
Temporary works icons with dimensions.
Possible locations for each type
Planners can review the locations of temporary works

Construction Visualisation
Construction equipment needs for specific components and operating space
Installation procedures for components and installation sequences
Locations of temporary works at different times and space needs.

Fig. 3 illustrates the level of detail used . Zooming facilities exist and the deck detail displayed in the top left figure for instance is still 'all there' in the much smaller scale version of the deck in the top right picture. It can be viewed in full detail if needed by zooming in on the image of the deck in that picture.

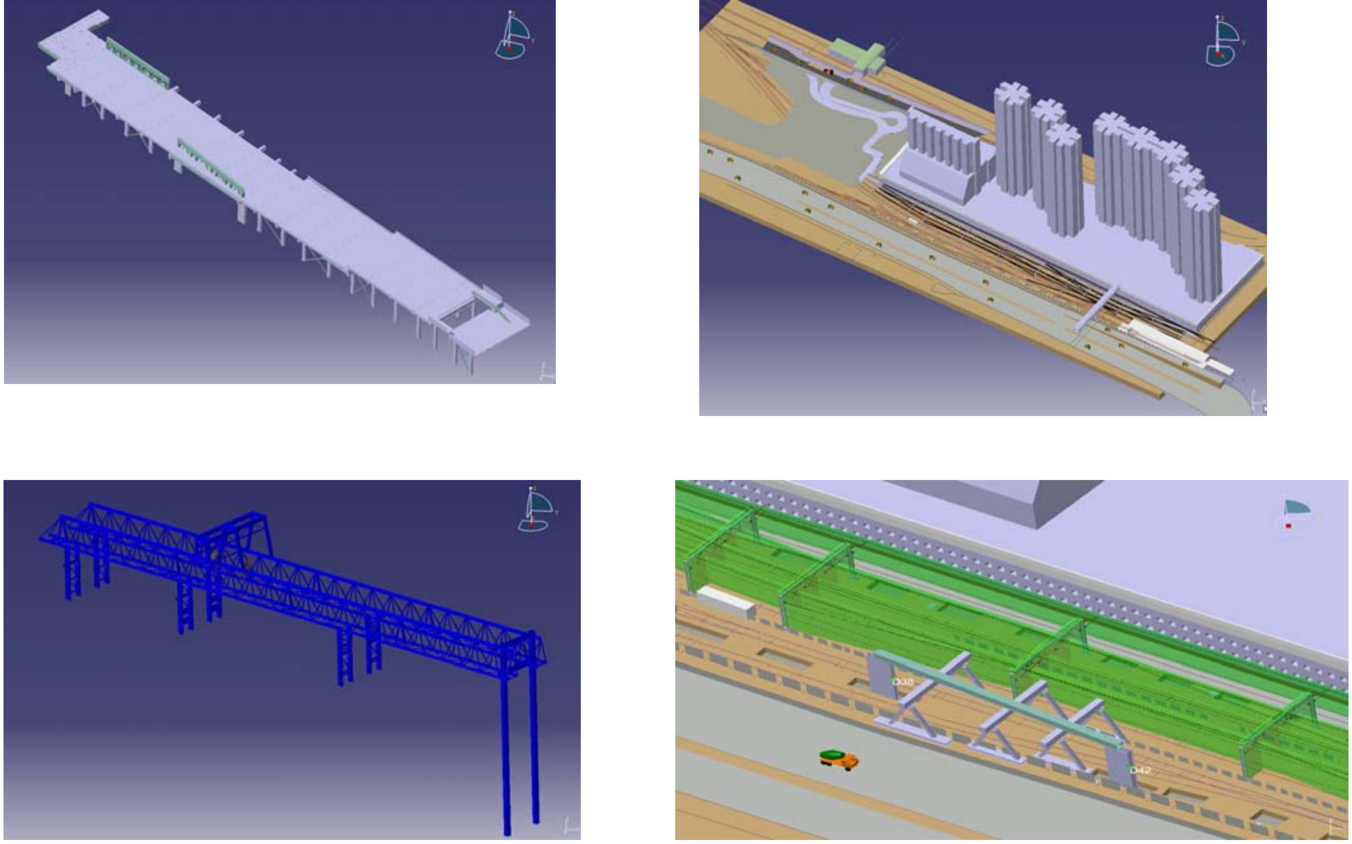

Fig. 3. 3D product and resource models of Ho Tung Lau project

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Method Verification Project

Three methods were simulated (mobile crane, mobile gantry, launching girder) and the pros and cons identified in moving and working the equipment.

The launching girder method was provisionally selected and the planners then had to ensure its smooth operation and non interference with the railway line furniture and the power cable by undertaking detailed, step-by-step, simulation of the construction process. During this simulation, problems were identified and corrective measures taken.

Detailed Simulation and Delivery Instructions

This is the stage of simulating the detailed individual operations and Fig.4 compares the model on the screen with a photograph of the actual operation taking place
.

Further Model data as follows was needed and was input at this stage.

- Operating locations of Equipment
- Sizes and quantities of components
- Temporary works space take up

The simulations include digitally developed activity sequences with durations digitally estimated based on the available working space.

A complex activity sequence for a subcontractor often needs a learning period for field crews. A series of pictures extracted from the VP model was used to give subcontractors and field crews a visualized work instruction (Figure 4). The project team found that the visualized work instruction was understood readily and was more effective than verbal instructions only.

Conclusions

The development and application of VP technology in the construction industry is relatively new.. VP usage can assist planners to eliminate or at least much reduce risk before the commencement of a project. Practical trials on real cases are going well and use of this innovative approach to planning and managing will gradually become mainstream . The investment in personnel to manage the software imposes additional overhead at this stage of development.

The benefits of using VP can be summarized as follows:

The creation, analysis and optimization of construction schedules. Effective constructability analysis. Elimination of risks through digital mockup. Clearer understanding of project scope and clearer instructions to subcontractors. Effective communication for all parties. Effective management of design changes Better capture and reuse of knowledge.

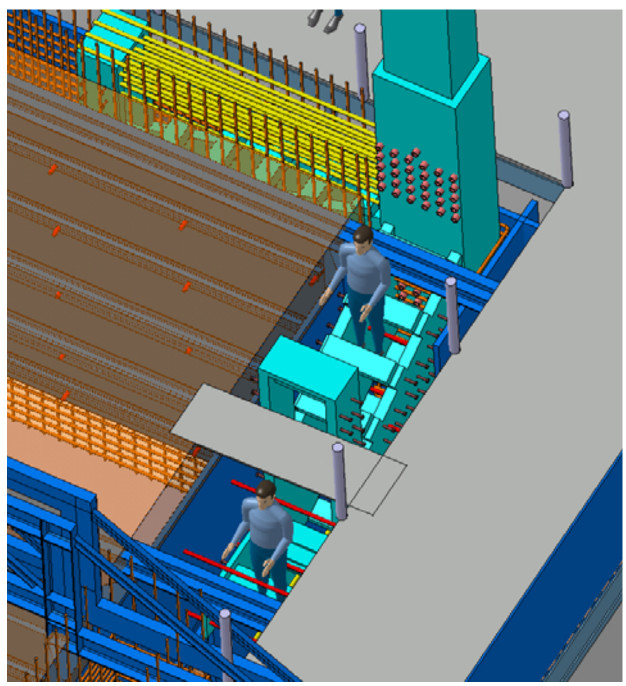

Fig. 4 .Visualized work instruction versus the real installation

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INNOVATION 2. –INNOVATIONS & BENCHMARK BANKS

An innovative model for the sharing of project experiences among construction businesses

The Hong Kong Demonstrations Projects Committee

As a means of bringing about continuous improvement in the construction industry, as demanded by the CIRC report referred to above, a number of construction organizations came together on a voluntary basis . The Hong Kong Demonstration Projects Committee became established in 2003 as a result, as a non-profit making association of construction industry organisations and business units. They agreed to deliberately SHARE their experiences of the use of new technologies and processes and CONTRIBUTE to the building up of performance standards benchmarks which are actually being attained in practice.

There are currently about 30 members , a Coordinator (an Honorary position) , a Group Secretary and a Website Coordinator. Members pay an annual fee. The Chairman is the Chief Executive of one of the largest Hong Kong contractors.

The sharing vehicle used is a Demonstration Projects Website , which is supplemented by newsletters containing extracts from the website in short form for highlighting by circulation.. The aim is to showcase Best Practice and Innovations. So far data relating to 26 projects are shown on the website. They represent private client projects and public projects, inclusive of building and civil engineering works.

The Demonstration Projects Website - www.hkci.org

The website is structured into:

Project Details, including team members and contacts utilized
Key performance indicator measures achieved. (KPIs)
Innovations involved (technological/process)

The KPIs are seen as Benchmarks of Industry performance.. Over time, those good, poor and average performances actually being achieved for particular types of construction activity will become common knowledge (but not names of the stakeholders for good reasons). Thus, rather like the records of sporting performances which are continually being improved, so will construction firms strive to improve on existing benchmarks, setting in motion a process of continuous industry improvement in performance. Nevertheless there is as yet no consensus on how to express KPIs—in what units and what levels of detail. The figures currently being given are valuable in themselves of course, but this is only the necessary start. Added value will appear when, through experience and discussion, there is consensus on the key indicators which should appear on projects and how to measure them. Only then can an industry collectively monitor its performance standards and pull itself up by its bootstraps sure in the knowledge that the improvement is real and having a measure of that improvement.

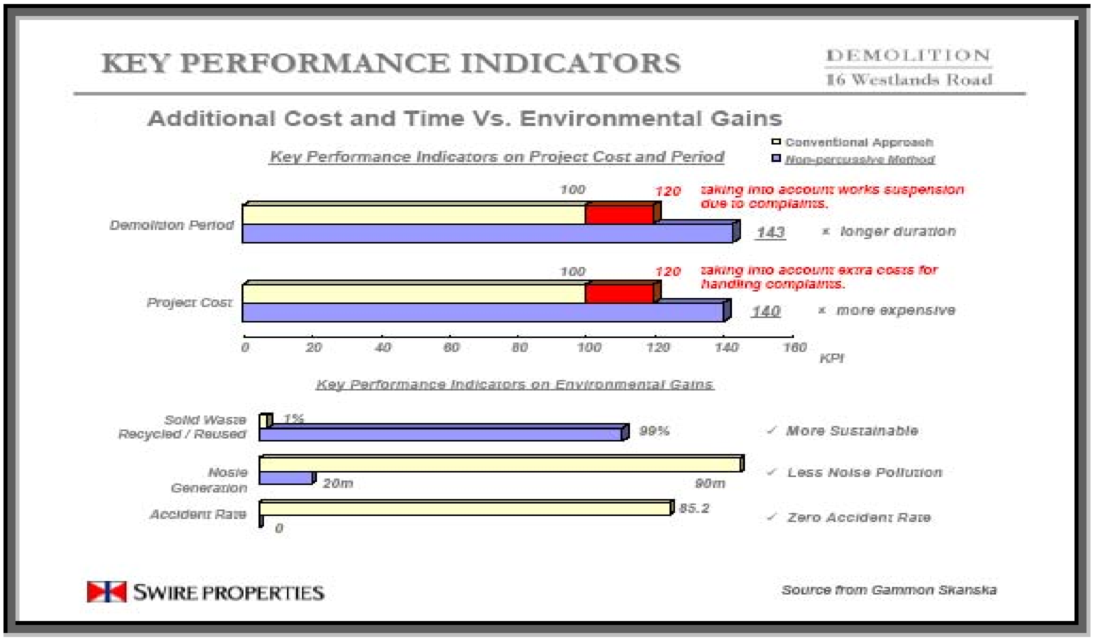
The reported innovations, too, effectively form an Innovations Bank providing practical experience data gained with each particular innovation. The existence of this bank will encourage the use of those innovations by others and cut down process learning time and help develop the required innovative culture.
It is not necessary to wait until a project is completed before submitting materials to the website. The Committee welcomes data entries on current projects , which after all can take many years to complete. Entries can then be brought up-to-date from time to time as required..

There is a website editorial panel which vets draft submissions against its established criteria.

Some Examples of Information included on the Website

These samples are included purely for convenience to give an outline flavour of the type and range of content. Readers would get a much better picture by accessing the website directly.

- On a 70-storey prestige building 3D solid modelling for simulation purposes and communication is being integrated with activity planning schedule and costs computer files. A change in any one file is automatically reflected in the other two. This application is very much in line with INNOVATION 1 above, but for a massive project on this scale such software requires three or four people full time for its operation in the service of the construction team.
- Demolition by machines which crush concrete with a 'biting' action reduce noise, dust and allow recycling of the old concrete.. Some of the performance indicators presented show that time and costs of demolition increase by 20% but the acceptable noise radius starts at a distance of only 10m, 99% of the concrete is reusable and the accident rate , in this case at least, was zero .

- 

- Source: Benchmark (2006) (Courtesy of Swire Properties)

- Another project presents a submerged pilecap claimed as an innovation in relation to a bridge structure crossing Deep Bay from Hong Kong to mainland China. The purpose is to lessen interference with water flow in the bay.
- A new science park is described for which the opportunity was taken to use advanced materials and methods as a deliberate policy. Such as double skin walls, automatic sun shading devices, special glass low on heat transmission and high on light for example. Modular design philosophy was adopted and much prefabrication of structural and mechanical parts. Formwork and falsework were all recyclable.

Conclusions

The willingness of competing firms to pool data in this way for the benefit of all is particularly interesting and important. It shows that the mood in the industry in Hong Kong is indeed to reach high standards of performance and demonstrates faith in the belief that sharing experiences will lead faster to an improved industry for all.

The development of KPI measures and just what specific KPIs to monitor across all contributors is a challenge being addressed . The importance of getting this right in the interests of most quickly upping average performance standards across the industry is obvious.