CLC LECTURE

Changing the Way We Build

28 July 2017

The Building and Construction Authority champions the development of a safe, high-quality, sustainable and friendly built environment for Singapore; one that is supported by progressive, technologically-advanced and globally-competitive firms and highly-skilled workforce. In this lecture, Dr John Keung will focus on the sector's transformative journey in construction productivity and BCA's role in shaping this change.

Lecture Segment

Zeng Han Jun
00:00:16

While encouraging the private sector to transform and innovate, he also walked the talk by having BCA to start the BIM-based energy and facility management pilot project, that uses smart sensors to optimise the building system.

On top of that, BCA Academy has also partnered Stamford University's Centre for Integrated Facility Engineering to offer training in BIM for CEO and middle management level. Sharing BIM best practices was just one part of the equation. He also managed the Singapore dollar, $800 million Construction Productivity and Capability Fund. This fund comprises incentive schemes that focus on work force development [and]

00:00:58 technology adoption in the Singapore built environment. Okay, so enough for the brief introduction on Dr John Keung.

Now, the format for today's lecture will start off with a presentation by Dr John Keung, followed by a Q&A [questions and answer] session with the audience. The lecture will be moderated by Professor Thomas Schroepfer, Professor of Architecture and Sustainable Design and the Director of Advanced Architecture Laboratory, Singapore University of Technology and Design [SUTD]. With this, I would like to invite Dr John Keung to this stage. (Applause).

Dr John Keung
00:01:35 Well, I'm quite sure all of us know—it is a common knowledge that the built environment sector played a very critical role in nation building, in transforming Singapore within such a short time—five, six decades—from a very small city overcrowded with squatters and so on, to the modern metropolis that we know of today with world class urban structure[s when] compared to many other cities. And as all of you know, in the early years of nation-building, our sector, the built environment sector helped solve this very urgent housing problem. And from there, we went on to build up our key infrastructure[s] to enable rapid industrialisation and all these socio-economic development[s] we have seen in the last three, four decades.

In the last 15 years, just to set the context, the volume of our construction work went up by almost 300%—from $10 to $12 billion thereabouts in 2003, 2004, to today $39 billion—that's 2014, 2015. And I believe that the outlook of our sector, although it doesn't look too good at this point in time, maybe this quarter and next quarter and so on. But it will be positive, will remain positive at about $28 to $35 billion this year, next year and the next few years, largely supported by public sector project[s] with a very significant proportion of civil engineering type of work—railway, and so on. Beyond that, we also expect the momentum to continue, given the many longer-term major project[s], as announced by Prime Minister and ministers about the Great Southern

00:03:47 Waterfront, the mega port at Tuas and of course eventually the redevelopment of Paya Lebar Airport—so this is the big picture so far.

Labour-Intensive Industry: Changing Times

00:04:00 But really what was our industry like eight, ten years ago? While I said earlier we have built a modern metropolis, and we've been talking about the need to raise productivity for *many* decades, easily three decades—productivity improvement particularly in the construction sector. But I must say that even eight, ten years ago, our sector still remained one of the most labour-intensive sector[s] in this economy. So take a look, in 2009, our construction workforce stood at 360,000—and as all of you know, [the] overwhelming majority being the basic skilled, inexperienced foreign workers from the region. And [for] labour productivity, however you measured it, whether value-added or site productivity, remained low—actually very low when we compared with other similar cities.

So the question is: what led us to such a, I must say, sorry state of productivity level and the presence of such a huge number of inexperienced foreign workers in this industry? I believe one of the key reasons is that given the international pricing of construction material and other financing factors, one way to keep the overall construction cost as competitive as possible when compared against other cities in the advanced economies, is to keep your labour cost low. So even though we have low productivity, even though we have [a] huge number of foreign workers, but our construction cost all this while—probably even until today—is the lowest among all the advanced economies when you compare with London, New York and even Hong Kong.

So as all of us know, having a large number of foreign workers also brings along other social problems, social cost—maybe they are less quantifiable but these are real costs and real problems. And it is also unsustainable and undesirable in the long term. You just take a look:

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years ago, we used to have many workers from China, PRC [People's Republic of China], China. This has dropped very significantly. Why? Because of the development in China. And I think the same is going to happen sooner or later in other regional countries where our foreign workers come from. So it is unsustainable, it's undesirable in the long term.

But you see, when you have a depressed wage environment, labour cost is low and [the] easy availability of cheap, foreign workers is a strong deterrent for technology adoption, because companies will naturally be very reluctant, extremely reluctant, to invest in costly but productive technology. The other problem I want to point out is that the built environment sector is a very conservative industry—we seldom try anything new. As I said before many times to many other audience, had HDB not pushed for precast construction in the early 80s, even though [*sic* while] knowing the cost is going to be higher, there will not be a precast industry in Singapore today.

For a long time, there has been a lack of collaboration among our stakeholders within the entire construction value chain—you know from developers to consultants, architects, engineers, and contractor[s] and all the way down to facility managers. They all worked within their own silo [with] very little collaboration, real collaboration across the entire value chain. So without proper collaboration, proper communication to link the upstream design with the downstream construction and facility management, it has led to many undesirable consequences, like unproductive costly rework: we went to the site, this is wrong, hack and redo. All these are wastage of manpower, wastage of resources, and of course lower productivity as a result.

So at that time—eight, ten years ago—while our industry was struggling to cope with the increase in demand, you know double, three times the kind of construction volume, the outside world in the US, in Europe, in Australia, things are rapidly changing. First, most of these advanced

00:09:39 economies increasingly realized the need to embrace environmental sustainability with all this global concern about global warming, climate change, energy security, et cetera, et cetera. So that's number one.

One other key change, second, was that there was a lot of not-so-quiet digital revolution. The use of infocomm technology in the built environment sector in many of these other cities, in the form of building information modelling, 3D [three-dimensional] BIM, virtual design and construction—you do your design virtually first before you go to the site to do the real thing. You know they are harnessing the power of infocomm technology in future-proofing their sector—the built environment sector—and they transform as a result of the way they work. The process of construction changed. So [it was] very much like the digital revolution in the manufacturing industry, transportation, telecommunication industry, but it was not happening here.

Third, the shortage of manpower and the very high manpower cost in all these other advanced economies also drove the entire built environment sector in all these economies to adopt productive, advanced construction technology, and embrace this concept of design for manufacturing and assembly—meaning that you do as much construction work [as possible] off-site in a factory, rather than on-site. So what did we do at that time, eight, ten years ago?

Revolutionary Changes: Raising Productivity

00:11:42 Well, I would say fortunately, given the recognition of all these social problems created by the presence of a huge foreign workforce here, and the heightened concern over environmental sustainability—particularly the impact of urban development on climate, we decided that we need to pull out all stops to raise productivity in the industry and to give the green building movement a big push. Well, to make it work, we need a paradigm shift—incremental change is not going to help. We need, really, to change the way we build. Well, in changing the way we build, I want to share with you, we actually witnessed the beginning of three

00:12:42 revolutionary changes in our sector in the last eight, ten years thereabout. Let me elaborate.

First, the green revolution. We started our green building journey in 2005, by launching our own BCA Green Mark Scheme, [a] building rating system to evaluate how environmentally sustainable that building is for the tropics—energy efficiency, water conservation, good indoor environmental quality, reuse, recycling of materials and so on and so forth, under this so-called Green Mark Assessment Scheme. So, from a mere 17 Green Mark building project[s] in 2005, we have now more than 3,000 such green building project[s]. Mind you, it is about one-third, one-third of the entire building stock in Singapore, including existing building[s]. I think no other city of our size has achieved anything close to that—and all these were done through our three successive green building master plan[s]. And really, I don't think there's any city that has done something like what we have done in such a short time. And of course, you all know that beyond that we have set ourselves an even more ambitious target: 80%, eight-zero, of our entire building stock to be Green Mark certified by 2030. And I'm confident this can be done.

Besides greening our city, we are also committed to mitigate climate change beyond our shores, outside Singapore. Today, we have more than 300 projects in 80 cities, 14 countries—tropical, sub-tropical countries in this region. And they have used the BCA Green Mark Scheme to evaluate *many* of their building projects, looking at their performance from the environmental sustainability point of view. We also collaborated with the United Nations Environment Programme, I think now they call it UN Environment, to formally establish the BCA Centre for Sustainable Buildings in 2011. This is the first such centre in Asia, and I think one of the three or four at the most in the world. I believe one was in Mexico City, the other[s] in Paris and Singapore. And the whole point of having a centre like this is really to share our experience in driving the green building movement, and embracing

00:15:42 environmental sustainability and urban development for regional countries here. So many of our staff in this centre are going out to talk to Indonesia, Philippines and so on and so forth together with UNEP [United Nations Environment Programme] to help the government and the private sector to see the need to go green.

To sustain the green momentum, at that time we aimed to train 20,000 green-collar workers by 2020. Today, through the efforts of the BCA Academy, and also our universities and polytechnics and other institute[s] of higher learning, we have trained 15,000—three-quarter of our target by now, you kno w, green workers at all level from certificate to degree, covering design, construction and maintenance of green buildings.

Well, so much on green. The next revolutionary change is the digital revolution in the built environment sector. Our aim is really to use this IT tool to break down the silos. So, it's not just changing from 2D [two-dimensional] CAD [computer-aided design] design to a 3D BIM design. It is more than that. It is a very powerful tool to help break down silos, to enable the developer, architect, engineer, contractor, subcontractor to work together as a team, ideally from day one.

Well, digital engineering, I'm using this term to describe BIM and VDC—virtual design and construction—is really, as I said, a process to integrate all this design, production, prefabrication, construction, et cetera, from day one. And in addition to this, today we have seen quite a number of consultant[s] and contractor[s] using it to simulate the construction process. As I said earlier, we build twice: once virtually, before you go to the site to build physically. To kick-start the adoption of BIM by the industry, we started—I believe that's the first in the world—to accept BIM submission for all regulatory approval—not just BCA but the other regulators too in 2010 on a voluntary basis. And as you know, we did this all the time, progressively we make [*sic* made] it mandatory requirement for BIM submission for all architectural, structural, M&E [mechanical

00:18:41 and electrical] drawings for new building projects with floor area[s] of more than 5000 square metres, two years ago.

So [in] July 2015, two years ago, we made it a requirement to submit BIM for all regulatory approval. That's the first step. But you see, to reap the full benefit of BIM [with] full collaboration among the stakeholders, I must say that funding support is very important. So we provided funding support using our BIM fund, you know this $800 million he was talking about, to build capability in the industry to use BIM, to use VDC. And public sector leadership has been a key approach that we adopt[ed] to generate this momentum. So since July 2012, about five years ago, more than 20 government procurement entities—HDB, LTA, et cetera, et cetera—with more than 200 projects, [began to] include this requirement for BIM, collaborative BIM in their contract. That means as a contractual requirement they require the architect[s], engineers and contractors and subcontractors to work together using the same version of the BIM model.

Well, to help the smaller guys, the SMEs [small and medium enterprises] the smaller firms to come onboard this BIM journey, we have set up a Centre for Lean and Virtual Construction, CLVC, in the BCA Academy. It is the first fully integrated large-scale immersive and experiential learning facility in Southeast Asia. We set this up last year basically to provide a low-cost space and facilities for these other teams in the industry who may not have the potential or the capability financially to do [up] their own [facilities], to make use of this facility to work as a team from day one.

And through the effort of the academy, the BIM vendor, private sector and also the IHL [institutes of higher learning], universities and so on, by now we have trained more than 8,000 BIM personnel for the industry—and we are on track to hit this target of 13,000 BIM practitioners by 2020. Over the years, we have also observed a progressive increase in BIM adoption by both our larger and smaller consultants and

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contractors. So for example, almost half of our bigger consultancy firm and about 15 percent of the bigger contractor[s], they have adopted both BIM and VDC—not just BIM—and VDC also in their work. And many of the smaller firms are now using the funding provided by BCA to acquire these basic BIM skills, hardware, software and so on, which I think is a very encouraging sign.

The last revolution: technology revolution. BCA has been championing very aggressively, I must say, the adoption of prefabrication technology along this entire continuum of Design for Manufacturing and Assembly [DfMA] since 2010. Our intention is really to achieve a quantum leap in productivity, not just incremental improvement. And DfMA covered the entire chain: architectural, structural work, M&E, plumbing work—everything that you have in a building looking for prefabrication, modular solution[s]. Of course, different types of project have different needs and they can choose to adopt a mix of all these productive technologies along this DfMA continuum. Our target is to achieve a 40%, four-zero, adoption rate of this DfMA across the entire continuum by 2020. Today, we are [at] about 10, 12%. This is a stretch target, but I think if we don't do any U-turn[s and] we keep charging, it can be done.

As I said earlier, under this whole DfMA idea, we are looking at moving on-site process[es] that are usually carried out under the hot sun in the construction site, under very hot, dusty and I must say very messy, very unfavourable conditions—offsite to a sheltered factory, where most of the process can be optimized and many can be automated. So, the completed component in the factory or the modules, depending on what you are doing, it could be a prefab bathroom, it could be an entire hotel room, built in a factory; and you move this module to the site and assemble them on-site.

Imagine, we are changing the construction industry into very much like manufacturing industry: build as much as possible in the factory, do as little as possible onsite.

Zooming in on DfMA: Changing the Industry

00:24:51 Let me take this opportunity to share with you a short video on the early adopter of steel PPVC—PPVC stands for Prefabricated Prefinished Volumetric Construction, meaning building something the Lego way. The Crowne Plaza Changi Airport Hotel extension. Well, some of you may have seen it or may even stay at this hotel before but what you might not know is that this extension wing, the extension of the existing Crowne Plaza Hotel was actually constructed with steel PPVC. All the hotel rooms, all the boxes, are [*sic* were] built in the factory, and this factory is in Shanghai. So after they built the hotel room in Shanghai, they moved it to Singapore to install, to stack up. So let's take a look.

(Video plays from 00:25:46-00:27:00)

00:27:00 So as seen in the video, the extension wing was built the Lego way and completed quite a number of months ahead of schedule. It has achieved a manpower saving, [an] overall project-level manpower saving [of] 44%. I believe this is a very significant benefit to the client and of course, to the industry. And I was told [that] from the second-storey hotel rooms onwards, excluding the foundation and the structure, to the ninth storey, the top nine or ten storeys—can't remember, 230 rooms, it was built in 27 days. 27 days! 27 working days.

There is always this misconception, especially when I speak [*sic* spoke] to the architects in the early days that this Lego-like method will result in very dull, modular, rectangular, square boxes—all these ugly-looking buildings. This is of course not what the architects want, or not what any of us wants. But this is not necessarily true! Here are some of these examples elsewhere: award-winning designs constructed using the Lego method.

Of course, there are many teething issues to resolve when we bring this technology to the industry. But there are many benefits to such an

00:28:51 approach too. I'm sure you can imagine: it enables automation when you do more work in a factory, more extensive mechanization, and better quality control in a manufacturing environment. And of course, our construction site[s] would be safer, cleaner, less dusty, less noisy! Indeed, the negative impact of a construction site on the surrounding neighbourhood would be much reduced, because you will take a shorter time and you are doing much less work on the construction site because most of this work is done off-site. And I believe going forward for infill development in Singapore in particular, in such a high-rise, high-density environment, this kind of technology brings more benefits than just productivity improvement. I believe pushing for DfMA, particularly at the extreme end like this PPVC idea, was one of the most difficult parts of our journey in the last 10 years or so, in really changing the way we build.

We took a multi-prong approach, as usual, by cutting down first, the worker quota—the MYE, Man-Year Entitlement for all projects, I think by 45 per cent. And we raised the Foreign Worker Levy very substantially—[by] four, five times. The whole idea was to narrow the labour substitution cost for technology, and [that] got our industry to think and rethink the way they built by turning to more productive, technology-driven method[s] and processes, instead of staying with the tried and tested very labour-intensive [method] of construction work. So to encourage an industry-wide adoption of DfMA, we also leveraged on our regulatory levers, well, that's BCA, we're a regulator too, under our building permit system. We raised the buildability, the constructability score by getting not just our architects and engineers to design building[s] that are easy-to-build, we also got the contractor to make sure that they used the most productive, labour-intensive method during construction.

But you see, all these regulatory measures would have limited success if they were not complemented by incentives for our industry to change direction[s] to cut down our reliance on manpower, particularly foreign

00:32:05 worker[s]. So to this end, as it was said, we have gotten the government to set aside $800 million under this Construction Productivity and Capability Fund, CPCF, with all kinds of funding scheme[s] to fund training, technology adoption, et cetera, et cetera. The whole idea is to help defray part of the cost increase in the adoption of this technology. Because the learning curve, I must say, is extremely steep and as a result there is a cost premium, even until today. So, if there is no incentive to help defray part of this increase in construction cost, it's not going to work. So to create demand for this technology, we also got our public agencies to walk the talk, to work out their own productivity roadmap[s] for all their bigger or repeated projects. The whole point is to get them to help to meet this national target of 2[%] to 3% productivity improvement every year.

So through the effort of MND and BCA, now almost all our key public agencies—you name it, they've done it, they have their own productivity roadmap. We also require[d] our public agencies to change their procurement practice. So it's not just price, not just simple quality, we have added this productivity element in the tender assessment at the expense of price. We are saying that we recognize the productivity of our industry, our companies, contractors, et cetera, et cetera, in public tender[s]. And this is really our way of rebalancing this value-for-money approach in public sector procurement, with price on one hand, and quality and productivity on the other.

Anchoring all these change[s] is the need for capability building in our industry. So besides helping our tertiary institution[s], IHL universities and so on, including ITE [Institute for Technical Education] to improve their curriculum and to meet all these changing needs of the industry, we have also built our own educational arm. That's the BCA Academy, to provide all kinds of programme[s] to drive all these change[s] from certificate to degree level, executive supervisor[s] and so on and so forth—so that the more they know, the more they practice, they have confidence to move ahead with this new technology.

Moving Forward with the Technology Revolution

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What have we achieved so far after doing all these under technology revolution in the last seven, eight years or so? First, site productivity improvement is defined as the floor area completed per man day. In other words, the same square metre of your condominium project, how many man day[s do] you need to do the same, year after year? It has been improving since 2010 so the CAGR, the Compound Annual Growth Rate, from 2009 to 2016 last year was a respectable 1.4%. And the total improvement is exceeding 10%. And in the last three years [from] 2014 to 2016, [it was] 2% every year. This has never happened in our industry [for] all these years. Of course, these are encouraging, but more has to be done to meet our very stretched target of 2% to 3% a year by 2020.

[For the] upgrading of workers, we have also built up a more experienced and higher-skilled workforce. I said just now, 10 years ago, most of our workforce on site were inexperienced workers. When we started in 2011, 2% of them were considered higher-skilled, meaning that they worked here for at least four years, passed a test by BCA on that particular trade and they are classified as higher-skilled worker[s]. [We had] 2% [in] 2011—today 40%, four out of ten of them are in this higher-skilled category. Of course, they are more productive, hopefully more safety-conscious, but definitely they are more able to look after the work that they are doing.

These are all, I must say, small initial success[es]. More significantly, I believe we are really at the very beginning of a new era for our built environment sector with these three revolutionary changes. We need to do more to sustain this momentum to fundamentally change our industry, change the mindset for the long-term growth and sustainability of our sector. So how do we intend to move forward? That's the last part of my presentation: what's our game plan for the next five, ten years?

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On green building we want to achieve breakthrough[s] in innovative and cost-effective green building solutions. We don't want just innovative and very expensive green building solutions. We want it to be innovative, new, produce result[s] and [be] cost effective for the design, for the construction and for the maintenance of our green buildings. So, the BCA Skylab completed last year—it is the world's first high-rise, rotatable test lab for the tropics. I think it is a step in the right direction. And this state-of-the-art test facility sitting on top of our seven-storey building in the BCA Academy features this 360-degree rotatable platform that can be angled to any orientation to the sun—so our architects and engineers can test almost anything they want under whatever orientation that they desire.

We are working together with the industry to develop this next green building roadmap. We have a vision: we want to achieve positive energy low-rise building[s], three-, four-storey building[s] generating more energy than they consume—positive. Our medium-rise buildings, we want to see whether we can achieve zero energy buildings, seven-storey, 10-storey buildings, zero energy. And for our high-rise buildings, we want to see whether we can stretch, push the envelope to have super low energy high-rise buildings. Let me explain. Today, our best in class, Green Mark Platinum building is about 30 to 35% more energy efficient than a normal code-compliant building. 30 to 35%. We are asking ourselves, for high-rise buildings, 20- 30-, 40-storey or higher, can we achieve 40[%], 50%, 60% more energy efficient [buildings]? Super low energy. That's our mission.

And this roadmap we are working on with the industry now will include strategies, technology development, innovation, policy change[s] and all these other R&D that we need to do making use of the Skylab and the other facilities in our universities, to see what we can do to really push the envelope to achieve this mission.

00:41:19 There is one project I want to mention: we are upgrading our current zero energy building. You know we have retrofitted the BCA Academy three-storey building eight years ago [in] 2009 to achieve zero energy—and we did. Actually, we did more than zero. We achieved [a] slight positive energy low-rise building. All in, every year we generate 5 to 10% more energy than we consume in that building which has a library—air-conditioned, offices—air-conditioned and so on.

So we want to upgrade this old zero energy building to a **new** zero energy building to see whether we can achieve a positive energy low-rise building and this positive part is not the 5, 10% we are [*sic* were] talking about; we want to see whether we can do 40%, meaning generating 40% more electricity than we consume. Again, this require[s] a lot of work, a lot of new technology—new way[s] of designing or redesigning our building. Other than that, we are also working on some other projects in the BCA Academy and also with the other[s] in the industry to see where this zero energy medium-rise or super low energy high-rise building can be [made] possible. Well, this is our way of walking the talk to really energise our industry. So that's on green.

Digital engineering, we need to push much harder, push **much** harder on collaborative BIM and VDC. We are not there yet. We have only a few teams who are able to do this today. But we want more, if not most in our industry to do collaborative BIM. So when our companies are more familiar with BIM, with VDC, we hope that they will look and move beyond 3D BIM e-submission, to tap on the many, many benefit of collaborative BIM for themselves. In fact, a few of our award-winning BCA BIM companies and public agencies have already moved into 4-D—I don't mean the 4D [four-digit], huh—four-dimensional, 5-D and 6-D BIM, to use BIM model to cost manage and to do facility management. And this is really our way of reaping the **full** benefit of digital engineering in this industry.

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On the technology front, much more has to be done to entrench the DfMA adoption. We need to build a robust ecosystem to create sufficient lead demand and to develop a healthy supply system; and also build DfMA capability within our people in the industry. So, with greater supply, cost of the DfMA technology will come down over time, definitely. We have seen this happen in our precast industry: economy of scale, wider adoption, cost will come down. So by then, we hope to have a more viable cost structure and this is a good thing. Lower cost will generate more demand, it's a virtuous loop. So to this end, in addition to public sector DfMA projects, we also need to do more to create demand in the private sector. And we have started doing that, we've been selling many of our government land sales site, condominiums in particular, with this condition to adopt DfMA technology, PPVC in that particular sales programme.

We have also worked with the other government agencies to raise the prefab level for our industrial land sale[s]. And we are trying out other new procurement tendering approach[es], this concept and price approach, without specifying any technology—but we specify the performance: you need to achieve 30% improvement in productivity, whatever, and you come up with the technology to do that.

Anyway, technological changes, as all of us know, are not static. We need to look for breakthrough[s] in this area too. And we have worked together with the industry on the productivity R&D roadmap, and we have identified seven clusters and 35 new R&D areas. And many of these are starting to get funding support from NRF [National Research Foundation] as well as MND. So, all these revolutionary changes in green building, digital engineering, DfMA technology and so on and so forth have really brought our industry to a turning point now. I believe the next 10 years will be very challenging for the industry—and to move together, we are again working with the industry on this construction ITM, the Industry Transformation Map for the Future Economy Council chaired by Minister Heng Swee Kiat. And we are going through the

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consultation process now with the industry, with the association, with the IHL at the same time to see whether we can *really* put all these together and set out a transformation map for our industry to go forward together.

So aside from productivity, innovation, collaboration, et cetera—they will all feature very prominently in this ITM that we are working on—but one key area that we are looking at is internationalisation, going beyond Singapore. And with global capital projects and infrastructure spending expected to grow, I was told, to a projected US$9 trillion by 2025, I believe our sector would be a key driver in all these changes and we must play our part. And I believe Asia, I was told, would account for about one...more than half of this spending, this $9 trillion. So these are really real opportunities for projects for our sector.

So to conclude, with our strategic location, our excellent infrastructure, and all these recent revolutionary changes in our sector in green building, digital engineering and DfMA, I think our companies are really in good stead as a regional hub to meet all these potential demand[s] in Asia. So finally, just let me take this opportunity to thank CLC for inviting me today to share with you many of these ideas on changes in the sector; so I hope everyone have a fruitful session after that. Thank you very much. (Applause).

Panel and Q&A Segment

Prof Thomas Schroepfer
00:49:33

I want to open the moderated part of the event by quoting the title of an article that the Business Times published earlier this year which is called 'Unfinished Business at BCA', John Keung. And many of the arguments that you made here today are also published in this particular article. I want to follow up on some of the things that you said about what actually keeps the industry from changing. And one of the main things, seems to me, the main obstacle seems to me is the low labour cost

00:50:14 **in Singapore. So obviously, that prevents companies from adopting technology, from investing in more technologically advanced solutions. So what can we do to change that?**

Dr John Keung
00:50:32 I must say that the reason why we have been keeping our labour cost low is really the fact that in the early years of industrialization or urban development here in Singapore, we needed to be competitive even in construction cost. So, as I said just now, I mean construction material[s], financing cost[s]—all these are more or less international, it is not determined just by Singapore, we are [a] price-taker. So the only thing that we can control is labour cost. So if you look at comparison, I mean in many advanced countries, you are talking about US$20–$30 or Euros per hour. I mean we are not paying that in any case. So, this cost concern after carrying on for so long, does let the industry accept the fact that we need to, or we should, use as much labour as possible to keep ourselves competitive cost-wise.

But then again as I said, going forward, this probably has to change because number one, the source of labour is changing, drying up in some countries, so you cannot continue to depend on the huge supply of workers. So, if you can have the current number of workers, but they are 30% more productive, you can do a lot more with the same number of workers—instead of [to] keep proportionally increasing the labour supply. But that is only one problem.

The other problem is really this mindset problem. We, as an industry, are not too collaborative. We, most of the time, [are] working in silo. And that really creates a lot of problems downstream. You know I was told there was some study done in the US that **even** in the US, because of this lack of coordination among the various parties, you can lead to 10%, if not more wastage when you actually go down to the site to build. So in our situation, [it is] probably worse. So it is really quite important for our industry to collaborate as much as possible, through the entire value chain. Maybe you can argue that in the past it's not easy, it's easier said than done. But now with BIM, all the parties can actually come

00:53:08	together from day one, iron out all their design clashes, design issues before they finalise their design—rather than wasting time from one party to another, like [in] the traditional way of working. And you can also use BIM to really simulate your construction process so you can plan, you can schedule properly, instead of [having] workers waiting for delivery on site and wasting time. And all these improvement[s] will lead to productivity improvement eventually. And as I said, once there is economy of scale, wider adoption of this technology and method, the cost will come down. And this has happened before even in our case, in the precast industry.
Prof Thomas Schroepfer 00:53:59	Maybe I can follow up on the discussion on BIM. I mean you are describing essentially a model that is much more collaborative, where people know the technology, where they can communicate through a shared digital model—how do you think these developments in technology in the building industry should be reflected in the way we educate architects, building engineers and so on? I mean the BCA Academy is doing a great job, but I think there can be more radical changes in how we bring up the next generation of building professionals.
Dr John Keung 00:54:37	Yeah, very good question. I suppose this is one area where [on the] university side SUTD is aiming to do, to get the architects and the engineer coming together to work on project, to probably study similar kind of modules so that the architect[s] know a bit about engineering and vice versa—and that I think helps a lot. But again as I said, it's really quite important for our industry first to get more such project[s] using BIM and using VDC. And one way to do this is procurement: how do you as a buyer of services, as a developer, as the employer, require a collaborative BIM? And we have been working with many public agencies, particularly those who have to look after their building year after year, for the next 99 years, if not longer. So it is very important for them to get the collaborative BIM so that they can, at the construction and the design stage, get a good value project. At the same time, when

00:55:46	they have the BIM model, they can use that for facility management subsequently. We are not there yet. We are starting, but there are good reason[s] to do all this. So once the industry is able to practise using real project[s], doing real collaboration, I think that's a very good starting point. And these are the kind of thing[s] I believe that our industry practitioner[s] should share with the universities. Maybe the universities should engage more of them as professor[s]-of-practice, or whatever—so that they can share all this really first-hand knowledge on what is happening in the industry with our students; so that our students, when they graduate, they are ready. They are ready for BIM, they are ready for VDC, they are ready to collaborate.
Prof Thomas Schroepfer 00:56:34	I was very intrigued to see in one of the slides that you showed as the roadmap for the building industry in Singapore, that you showed kind of cutting-edge technology such as 3D printing also in the context of the large building scale. Can you elaborate a little more on where you see the potential? I mean we know there's already experiments in other parts of the world where for the first time we see entire buildings, small-scale buildings at this point, being 3D printed. Do you see this as the future?
Dr John Keung 00:57:06 00:58:12	Well, I suppose the short answer is yes, but it could be a long journey. and depending [*sic* dependent] on the technology you are looking at. So that's why for, I think, two years, we've been working with the industry, I was told 400 industry experts were engaged in 10 different teams, focus groups and so on, to look at all kind[s] of technology that are available now, or likely to be available in the future, or possible for the future. So that's where they worked together on this productivity R&D roadmap with these seven clusters covering almost everything under the sun: various types of technology, 3D printing, robotics, and so on and so forth. So I guess going forward, now that we have a roadmap like this, we are probably in a good position to get funding support, to really carry out serious R&D work with the IHL, with the industry together and see whether we can achieve breakthrough in any of these areas.

	And I believe that as long as we keep working on this and looking at possibility, it is entirely possible, 3D printing, robotics, it is things to come. You cannot wish it away.
Shih Min 00:58:24	Good evening, doctor. I'm Shih Min, I'm from CLC but I used to be a private sector licensed architect. And actually, I'm quite curious about the opportunities being offered because in traditional architectural design, we as architects are not really taught to consider structure, M&E or any of the things—quite often what happens is we do ideal design and then we start chipping away at this ideal design with the structures and beams. That's why often we have a nice form but there's a column standing in the middle of nowhere, looking very awkward, but we don't care. Do you think BIM would offer a more graceful solution to this, such that all the M&E, the structural element are integrated into the architecture nicely and we could eliminate any of these strange columns or strange pipes all the way in the middle of nowhere, so that it's no longer like...the two elements work much better together? Do you feel that there's an opportunity to do that?
Dr John Keung 00:59:22	Thank you for bringing this up. I think for those who work in our sector, you know very well that this thing happen[s] all the time. And I suppose in the past, without a 3D model, it's probably very difficult to do any such coordination. So I have seen a few of our recent projects making use of the academy, BCA Academy's CLVC, the Lean and Virtual Construction Centre—this whole idea of a big room concept. So in that particular project, the various parties came together including the developer, the architect and the civil, mechanical engineers sitting at the same table using the same screen—there are five screens but they are looking at the same model. And many of these conflicts, all these design clashes, can be detected relatively easily. So if you can detect all these and sort out the differences there and then, rather than another few days waiting for somebody to come back to you with a changed design, it is extremely productive. And many a time, when you sit down together to discuss certain problem[s], there are light bulb moments. You can find innovative solutions or cheaper solutions—

01:00:45	more effective solution[s] to your problem. So, detecting clashes in design is one of the basic functions of a 3D BIM model. And as I said, we should go beyond just [the] detection of design clash, because BIM can be used further downstream in the construction process and even in the maintenance process. We are starting. We are not there yet, we are still learning but I'm quite happy to see many of the bigger consultant[s] and contractor[s]—they are really embracing this and they've been giving us feedback: that if they do it well, it does help them save time and save effort.
Li Fang 01:01:28	Hi, I'm Li Fang, also working in CLC. This question originated from the video that I saw of prefabricated buildings through modular units. So what struck me was that there were a lot of walls. And my question is: would this affect the adaptive reuse of the building in future because you can't anyhow hack down walls? Thank you.
Dr John Keung 01:01:55	If you read some of this literature on modular construction, actually if you want to reuse the module, technically you can disassemble and move that hotel somewhere—technically you can do that. And I was told in the US, they use the same technology to build army barracks—all these hostel[s] for the soldiers and so on, dormitories—and they have done that. They have moved one to another just by disassembling the existing modular building and moving it somewhere else. So it's possible, it can be done.
Yulia Pak 01:02:39	I'm coming from Russia, the country which is much less advanced in terms of construction productivity and I'm really amazed by the achievements of Singapore here. The question is: I know that the Housing and Development Board is currently developing the concept for smart cities which is to be applied for existing and new housing estates in Singapore. Can you please elaborate on what elements of the three big areas that you outlined in your presentation can be, and will be, applied there for the smart cities? It's called smart city project, I think. Yes, by Housing and Development Board. I assume you know about this project but if not, then forgive me.

Prof Thomas Schroepfer 01:03:27	Is that a particular project or generally, you know an initiative by HDB?
Yulia Park 01:03:31	I think it's a framework. Basically, it's a concept which...okay, I mean if you cannot comment on this, it's fine. I apologize for assuming that you know about this.
Dr John Keung 01:03:42	I must say I don't know enough about this whole smart city concept from A to Z. But if you look at buildings, we believe that you probably cannot have a smart city if your buildings are not smart. And some of our green buildings even today, they are smart buildings. They make use of a lot of sensors to regulate the internal climatic condition. And one of the recent R&D project[s] in the BCA Skylab, they are looking at this integration of the cooling system with the blinds, and with sensors of course. So depending on the time of day, the angle of the sun, et cetera, et cetera, automatically the building adjusts and create[s] an optimal climatic condition internally. So, this is one component of a smart building. I'm quite sure there are more [that] need[s] to be done. Then in our sector again, I want to say also that if there is no smart construction, something is missing in the smart city. So smart construction will require a lot of use of digital engineering and also, this DfMA concept. So I believe that what we are doing or what we are seeing in the last 10 years does contribute to this creation of a smart city eventually.
Geh Min 01:05:08	I've always admired your work and I think you are building... It used to be said that Singapore is a first world country with a third world building industry. But I think you've convincingly demonstrated that you're bringing us up to first world there. I am of course not an expert on buildings, but I want to ask about the people, both the workforce and the users of the building. It seems to me that, of course I know this is not your purview, that the user, the eventual users should not just be passive recipients of smart buildings. And when you were talking about these blinds that will automatically sense the temperature, control, and

01:06:02

the amount of light and so on, I notice that a lot, just to give an example, I notice a lot of new buildings are very impressive, some of them have got Green Mark awards, but you can't open the windows! And so, you can't enjoy natural ventilation or the breeze; you have to depend on all these artificial and maybe very energy efficient... But I...so my question is how much do you interact with the people who are going to use the buildings and find out how they're going to use them? That's one point.

The other one I wanted, if I may, Mr Chairman, going back to the workforce, you talked about the emphasis on developing skilled workforce which I agree is very, very important if you're going to achieve your goals, now as far as...and I think you mentioned that for the basic workforce, you've increased the level of skilled workers from 2% to 40%. But we all know that a lot of this workforce is not Singaporean and...I am actually a medical doctor, we have a problem in the hospital where you train a lot of these technicians, nurses, some of them are very good, some of them are not so good, but we are not allowed to retain them because of employment pass[es]. So is this integrated? Can you retain skilled workforce that you have trained? And I suppose the other aspect of that question is do you think you can induce more Singaporeans to go into the building industry? Or to push it even further, since you are envisaging the future, we know a lot of jobs that's going to be replaced by artificial intelligence, robots and so on. In the medical field, we're already looking at which specialties will be replaced! Are you going to be...do you envisage a future of building industry where a lot of the jobs including the high-level ones, engineers, architects and all, can be done by a robot or at least by artificial intelligence? This is a provocative throw-in.

Dr John Keung
01:08:20

We'll just take it one by one. On the users, I must say that you hit the nail on the head. You know we have three successive green building masterplan. The first one, we focused on new buildings to get them build it right from day one. The second masterplan, we focused on existing building[s] so that they retrofit and improve their energy efficiency, et cetera, et cetera. The third green building masterplan was

01:08:48

on users because in 2004, 2005 and until today every year we carried out surveys for thousands of commercial, institutional buildings. We looked at their energy consumption pattern. Okay, not so surprisingly, in a typical commercial building, office for example, 50% of the energy consumption is from the user—it's your laptop, it's what you do with the lighting, et cetera, et cetera, your water heater and so on and so forth.

So, we realized that if we just look at the overall central system, the common area, we are not going to achieve the kind of energy saving that we need. And it is very important to bring the tenant, the occupier, the user of building[s] on board. So since two, three years ago, we started quite a number of programme[s] [for] public education, public outreach. We also did some of these pop-up stall[s] in commercial building, getting the officer workers to understand that the way they use their building is important. And if you cannot have all the sensor[s] to help you to switch off the light[s], you got to do it yourself, and so on and so forth.

We have seen some results. We are still not there. Some of the building owners, they do work with their tenants through some either incentive or CSR [corporate social responsibility] programme[s] to get them to come together to get BCA's Green Mark office interior rating—platinum, and so on and so forth. We also work with some supermarkets, I think in this case it's NTUC, to green their supermarkets so that they can look at how they can save energy. And tenants' involvement is really quite critical.

And today we have a whole range of user-centric Green Mark Scheme[s]: restaurants, data centres, laboratories and so on. And as you know, [the] data centre is [working] 24/7 all the time, so if they can retrofit, they can do something to make sure it's energy efficient, it helps a lot. So you're absolutely right. This user part is the most difficult part to do, but we must do [it]. And we must do more going forward.

01:11:13

On natural ventilation, I think some of the architects will probably know very well, I think we have been changing our Green Mark Assessment Programme to emphasise a lot more on natural ventilation. So instead of just using the most energy efficient five-tick air-con[ditioner], can you design in such a way that there are cross-ventilation, et cetera, et cetera? Again, I mean we are not there yet, we're extending this idea under our Green Mark 2015 to other types of buildings too. So there are [*sic* is still] some way to go, but the use of natural ventilation is the **key** element going forward. So you are quite right there.

Workers. Well, let's look at it this way. I suppose [that] given our construction volume and given our population demographics, it is probably quite important that we will still depend on foreigner[s]—probably quite a large number of them, in this industry. But what we want to achieve is this: number one, we want them to be as skilled as possible, and as experienced as possible. So for the last few years we've been working with MOM, Ministry of Manpower, to encourage our employers, contractors and so on to keep their experienced foreign worker[s] for as long as possible.

And they have tweaked the systems so that if you are a skilled worker, under this higher-skill category, you pay less levy. So in that sense, you can pay the guy a bit more and you will save eventually. And by doing that, they can also stay on longer—may not be forever, but longer than those who are not so skillful. So that's our way to shape the construction workforce, so that hopefully we can go beyond that 40% eventually. And I guess from 2 to 40% is an achievement, but [that is] not enough. We're probably got to do a lot more to make sure that our workforce is skilled, and they're experienced. And these are very important.

Your question on locals—in the last I must say seven years or so, we've been going **all out** to get as many local[s] to join this industry as possible. But you see, if we don't change the way we build [and] we still keep to the old way of building, look, it's an uphill task if not impossible, to get

01:13:44

more local[s] into this industry. So I have been telling my colleagues, as well as people in the industry that there is no point telling young people how glamorous this industry is. Once they go to the site, they know [what] reality [is]. So you must change the way you build first. If you can do more of this Crowne Plaza Hotel extension type of project, look, it's easier to get the youngster to look at this industry.

And in the actual outcome, I also want to let everyone know that in the last six, seven years, we have been giving out 2,500 scholarship[s] and sponsorship[s] to our local students: youngsters studying in ITE, studying in poly[technics], studying in all our universities, in all these built environment related courses—they are taking this up. And [for] last three years [since] 2014 to [*sic* till] now, every year I give out 500 such scholarship[s] to our local students. And I think it's a good sign; so at least they know that the industry is changing, it's going green, it's going digital. So when they use the 3D BIM model, it's like playing computer games—it is not very much different. So by doing that I hope we can get as many local[s] as possible for this industry, to really build up this local core eventually.

Your last one is a tough one, the last question. Robotic[s], I think is to come, especially for those more dangerous type of work. Like demolition for example, today some are already using robot[s] to demolish buildings. But eventually I believe that if we can get our industry changed in the way we think they should do: go green, go digital and use more technology, it is a plus sign. And the fact is that we don't have that many local and the foreign numbers are also dwindling, and when the other country are progressing, we probably cannot get as many as you want. So it is probably possible and desirable to have some part of the work, especially those more dangerous one, to use robots—or those backbreaking one[s], like tile-laying.

John
01:16:07

I think if you really want to talk about BIM it has to start with the school[s]. It cannot be [brought] into the industry and then people come in [to] try to learn BIM. The reason I say this is because when I first came

00:16:18 here, I was aghast at the NUS student[s] designing without any sense of structure. If you look at the plan, you know right away [that] it's just a two-dimensional plan on paper, [and] they have no idea [of] how the structural system work[s] at all. And eventually, I found out from the industry [the reason] why: because in those days, the architect would come up with a plan with no sense of structure, give [it to] the engineer and say, "now you make it stand up." Okay. And after that's done, the plan is passed to the M&E engineer, "now you try to squeeze everything in between the thing" and that's why we had this problem in the old days.

But to be fair, the construction sector has transformed tremendously [over] the last 30 years or so—I shouldn't say how many years, I'll give my age away. But I think you are right, you are on the right track, we got to push further [and] more to go into that integrated design concept, rather than you know, all [planning] in the little silos and then pass[ing] it to the next guy to fix the problem and everybody upstream will kick the problem downstream, kick the can down the road. So I think you are on the right track on that.

I'm happy that you mentioned the ITE programme. I've been to some of the award thing[s] that you have done, I think it's finally getting some traction with the students in ITE, especially the lifts and the escalator[s] because you see for the general work they're still a bit…not so sure about it. But once you say lift specialist[s] or escalator[s] or moving parts, now that grabs their imagination a little because they know that that is a skill they can develop further on in their life. They can do it for their whole life, you see.

But when you talk about say, tiling, carpentry and all that, it's a little bit still…not so grabbing for them. And so, I think BCA should work closer with FCL [Future Cities Laboratory] [on] the robotics part and then get the young kids interested in that—that means you don't do your back-

00:18:22 breaking work anymore; you're actually driving mechanical robotics to deliver what you want to do.

Now I want to ask a very general question about the hotel. Why was it done in Shanghai, and not say Guangzhou or some other city? That's the first question. Second question is, I'm curious, why is [*sic* was] it done by private sector? I would think that HDB would be the first one to do something like that. And when do you think HDB will try that Lego set idea? Thank you.

Dr John Keung
01:18:54 Actually the Crowne Plaza Hotel is not the first project using this PPVC concept. The public sector did the first one—that's the NTU, the Nanyang Technological University. They have built six blocks of hostels [which are], I can't remember how high, about 10 storeys or 12 storeys using this similar kind of concept. And these are hostel rooms, student hostel[s], so the idea is similar. So they have got that done. And they have also worked on the second project [which is] about to be finished using the same technology. So [the] public sector is moving, and I understand that HDB is also moving in the same direction, so very soon you will see similar kinds of technology adoption in public housing.

But I guess the point I want to make using this particular video is that for project[s] like hotels, hostels, apartments, et cetera, all these are very suitable for this kind of technology. It may not be the same for offices or other types of buildings like hospitals and so on and so forth. So it is quite important for our industry [to] not just look at this PPVC as the silver bullet, the only solution. There are many other technologies in this entire continuum called DfMA for you to adopt, whether it's architectural, structural or [on] the M&E part.

So many of our condo[miniums] now for example, even [if] they don't use PPVC, they are using prefab bathroom[s] as one of those improvement[s] that they are making, to make the construction process a lot easier.

Prof Thomas Schroepfer
01:20:31

Okay, I think we are getting close to the end of today's event. But before we let you go, Dr Keung, I want to come back to the Business Times article; and you know, enquire a little more about your plans because again the article is called 'Unfinished Business'. And it actually states that you plan to tear down some of the older buildings at the BCA Academy to build two new ones: a 20-storey high-rise building and another 7-storey medium-rise building using PPVC and mass engineered timber [MET] respectively. Any other plans you want to share with us?

Dr John Keung
01:21:08

I suppose it's probably not for me to say too much but these two project[s which] you are talking about, yes, we are working on it. And it's not just the use of PPVC and MET. We are also trying to see whether [for] this lower-rise 7-storey building, we can achieve net zero energy. And for the higher-rise, I think, 20-storey building, we want to see if this super low energy is possible. I mean we are still working on this project, so when there are updates of course we will let the whole world know.

But I must say that beyond the public sector [and] all these initiative[s] that they are doing, I think it's really quite important for our IHLs to come on board. I think that's John's point earlier—it is quite important for our student[s] to really look at this industry differently and for our professors to look at it differently. And it is really quite important that from day one, they understand that these are the kind[s] of things that they are going to do when they graduate, so they better learn as early as possible so [that] they are ready for the industry.

I mean from time to time, I still get feedback from the industry that after you got [*sic* get] this architect or engineer from the university graduating with very good grades and so on, [it] takes three more years for them to be functioning. So that, I think is probably not the way to go. That's why I suppose [we] all got to work together: we want to create more project[s], but this capability building is very important. And to me, in the academy we are trying to do that—not just at the PET [Pre-Employment Training] level but also [at] the CET [Continuing Education and Training] level for those working professionals. There are many such

01:23:01	courses for them to improve [and] to understand what's happening in the industry and hopefully they can also upgrade [themselves].
Prof Thomas Schroepfer 01:23:08	Well, that's why we have you on our advisory board. So, I think I'm going to wrap it up here. I want to thank CLC for hosting the lecture, and of course please give a hand to Dr Keung. (Applause). [Transcript ends at 01:23:19]

LECTURE INFORMATION

TITLE
Changing the Way We Build

SPEAKER
Dr John Keung
Dean, Building and Construction Authority Academy, Singapore; Former Chief Executive Officer, Building and Construction Authority

MODERATOR
Prof Thomas Schroepfer
Professor, Architecture and Sustainable Design; Director, Advanced Architecture Laboratory, Singapore University of Technology and Design

DATE
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MND Function Room

DURATION
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