Collaborative Workflows in BIM Project Management

BIM 프로젝트 관리의 협업 워크 플로우

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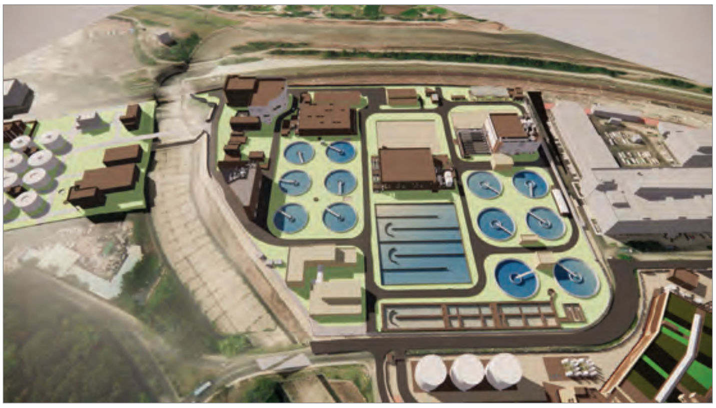
이 글은 BIM(빌딩 정보 모델링) 프로젝트 관리의 협업 워크플로우에 관한 것입니다. BIM이 적용된 건설 프로젝트에서 프로젝트 관리를 용이하게 하는 기술 도구, 협업 플랫폼 및 소프트웨어에 중점을 둘 것입니다. 홍콩에 위치한 폐수 처리장 건설을 사례로 선정하였으며, BIM 컨설턴트가 프로젝트에 사용하는 워크플로우와 도구에 대한 컨텍스트를 보여주고자 합니다. 그 프로젝트는 기존의 하수 처리장 리노베이션입니다. 현재의 리노베이션 공사는 2019년 말에 시작되어 5년 동안 진행될 것으로 예상합니다. BIM 컨설턴트가 BIM 프로젝트 수행하기 위해 협업 도구, 내부 프로젝트 관리도구, BIM 품질 관리 프로세스, CDE(Common Data Environment), 4D 시뮬레이션을 위한 도구, 더 나은 이해를 위한 시각화, 프로세스와 플랫폼, 향후 프로젝트 관리 계획이 필요합니다.
설계의 정확성, 시공 중 프로젝트 관리의 효율성, 최종 제작 품질 및 현장작업자의 안전을 개선할 수 있는 BIM 관련 프로젝트 관리 기술이 지난 10년간 상당히 진보하였습니다. 하지만 홍콩 폐수 처리장 프로젝트처럼 이런 기술의 효과를 보기 위해서는 엄격한 모범 사례, 도구 활용에 전념하는 프로젝트 참가자 및 높은 수준의 지시가 수반되어야 합니다.

This article is about collaborative workflows in Building Information Modelling (BIM) Project Management – the focus will be on technology tools, collaborative platforms, and software, that facilitate project management on a BIM-enabled construction project. The construction of a wastewater treatment plant, located in Hong Kong, has been chosen as a case study and will provide context on the workflows and tools used by the Independent BIM Consultant on the project. The project involves the renovation of an existing sewage treatment plant. The current renovation works began at the end of 2019 and is projected to last for five years 〈Figure 0〉.

Background on the project

The wastewater treatment plant opened in 1974, serving a population in the surrounding area of approximately 12,500 people and processing roughly 1,700 m^3 of sewage per day. However, the area was a rapidly developing part of Hong Kong – both in terms of population size and in terms of industrial and economic activity. A decade later, by 1984, the surrounding population had already increased by almost twenty times, to 220,000 people. The wastewater treatment plant was, therefore, expanded, allowing it to process 60,000 m^3 per day. By 2001, the population had grown to 300,000 people and the capacity of the plant was further increased to 80,000 m^3 per day and in 2009, the plant had reached it's designed capacity of 93,000 m^3 of sewage treated per day. At the time, it was projected that by 2034, the wastewater treatment plant would need to be able



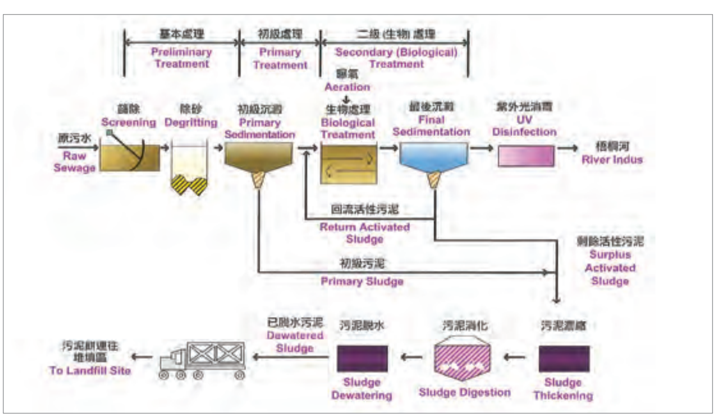
<Figure 0> Project

to process 190,000 m³ of sewage per day in order to support the needs of the surrounding region. Thus, in 2015, advanced works increased the capacity by approximately 12,000 m³ to 105,000 m³. The construction contract for the current renovation works, which is the focus of this article, will add a further 35,000m³, bringing the capacity to 140,000m³ by 2025. Future construction contracts are planned for the final 50,000 m³ of expected capacity.

The sewage treatment process

In order to appreciate the nature and scale of effluent processing facilities, it is helpful to have a general understanding of the sewage treatment process 〈Figure 1〉. Raw sewage undergoes preliminary treatment by screening and de-gritting. Screening removes debris – such as pieces of plastic, textile material, wood fragments, and some of the grease. De-gritting removes smaller particulate matter such as sand and fine gravel. The next step is primary treatment where a set of primary sedimentation tanks is used to allow even finer particulates to settle and accumulate at the bottom of the tank. This settlement is called primary sludge and is pumped out of the bottom of the primary sedimentation tanks. Then comes secondary treatment which involves cycles of biological treatment and final sedimentation. In biological treatment, microorganisms are introduced to the wastewater and aerated, allowing the microorganisms to metabolise remaining grease into organic matter and nitrogen. The organic waste settles in the final sedimentation process and the resulting sludge is referred to as activated sludge. The effluent water is then filtered or "polished," disinfected under ultraviolet (UV) light before it is released back into the river system as cleaned water.

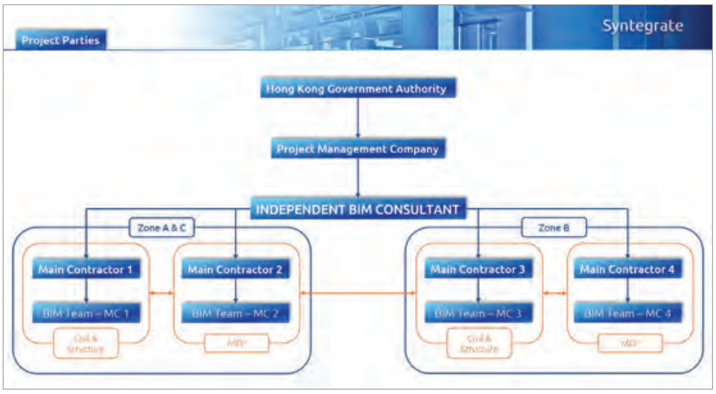
Meanwhile, the surplus activated sludge from secondary treatment is removed and mixed with the primary sludge collected from primary treatment. This sludge mix is then thickened, digested by bacteria in an anaerobic environment, and dewatered. The dewatered sludge is then taken by truck to landfill.



<Figure 1> sewage treatment process

Buildings and equipment systems

From the overview of the sewage treatment process, it should come as no surprise that the current renovation works include over forty buildings and equipment systems that are located over a site that is more than thirteen hectares in area. New buildings and equipment systems include the inlet works building, primary sedimentation tanks, bioreactors, membrane facilities buildings, chemical dosing systems, deodorisation systems, UV and effluent pumping station, sludge dewatering building, sludge digester, workshop building, thermal hydrolysis pre-treatment facilities, biogas holding tanks, sewage pumping station, waste gas burner, fire services buildings, and a 132-kilovolt primary electrical substation. And, as can be expected from a renovation project on a plant that was commissioned in 1974, much of the new construction involves pre-requisite demolition of old buildings or plant systems. Connecting all of the buildings and equipment systems is a vast network of mostly underground utility



<Figure 2> Roles

pipes. Finally, surrounding the new construction will be the reinstatement of tree-planting, landscaping, roads and access paths, streetlighting, and other site installations.

Project participants

The project owner is a department of the Hong Kong government. The governmental authority has hired a project management company to manage the construction process. The construction of the renovation works is split up over four main contracts with the works divided into two zones – each zone being the responsibility of a pair of main contractors. Each pair of main contractors is composed of one contractor in charge of the civil and structural works while the other, the MEP (mechanical, electrical, and plumbing) works. Each main contractor has their own BIM team 〈Figure 2〉.

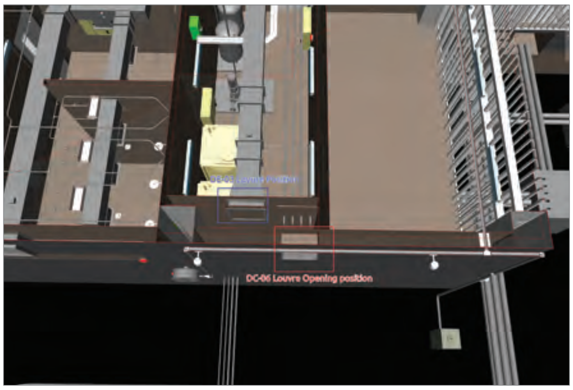
Obviously, between each pair of main contractors, who are responsible for a zone, are a lot of interfacing works. Additionally, between each zone of the project, there are also interfacing works. Therefore, the organisation of the parties both on a practical and contractual level is more complicated than on a typical construction project. This added complexity, has a commensurate effect on the BIM tasks that are an integral and critical part of the construction process. Consequently, the role of Independent BIM Consultant whose responsibility it is to oversee all of the BIM collaborative workflows, adherence to BIM standards, management of quality control on the BIM output, and the implementation of enabling technologies has been defined on the project.

Why we need collaborative tools

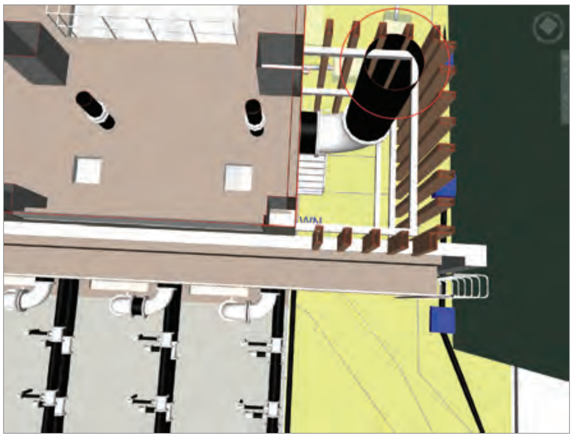
With the need to coordinate the BIM works for four main contractors and each of their BIM teams, especially with respect to the areas of their works where there is interface between two main contractors or between one zone and another, it is necessary to have a well-developed set of BIM processes and a set of critical technological platforms to rely on for the successful BIM-enabled delivery of this project. To illustrate these necessities, Figure 3 shows an example of 3D coordination at the Workshop building where a mechanical duct, terminating in a louver, is not aligned with the louver opening in the structure of the building exterior.

Figure 4 shows another example, taken from the Membrane Facilities Building, where a clash has been identified between a section of vertical pipe and the architectural cladding of the building. In both of these cases, the issue arises from the interface between the civil and structure main contractor and the MEP main contractor.

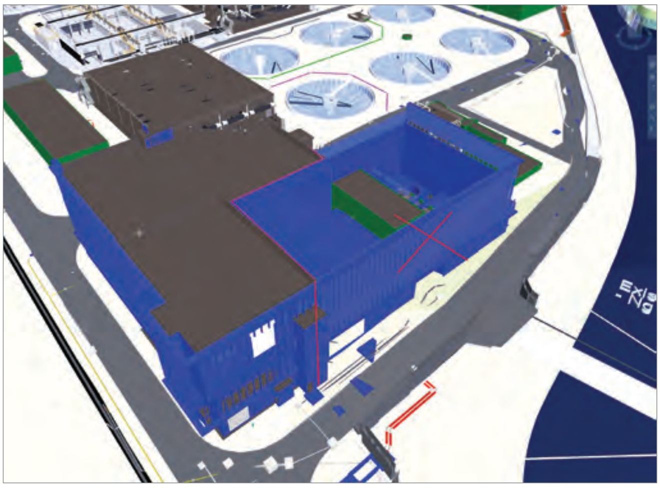
However, not all issues arise from clashing interfacing works. With all of the BIM content being created by the BIM teams of the four main contractors, a lot of quality control issues arise



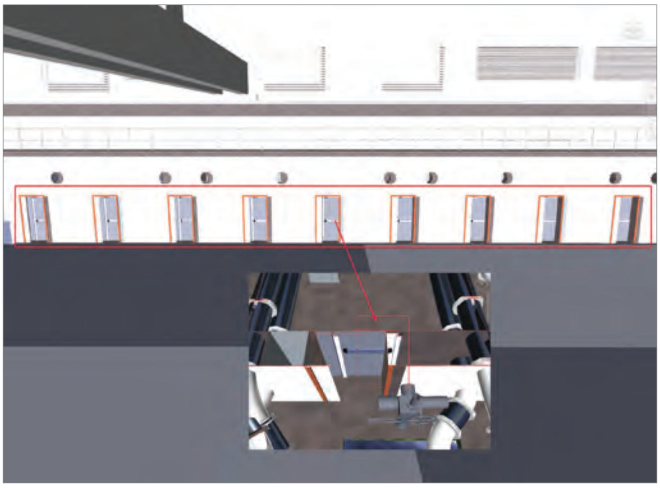
<Figure 3> Processes & Platforms 1



<Figure 4> Processes & Platforms 2

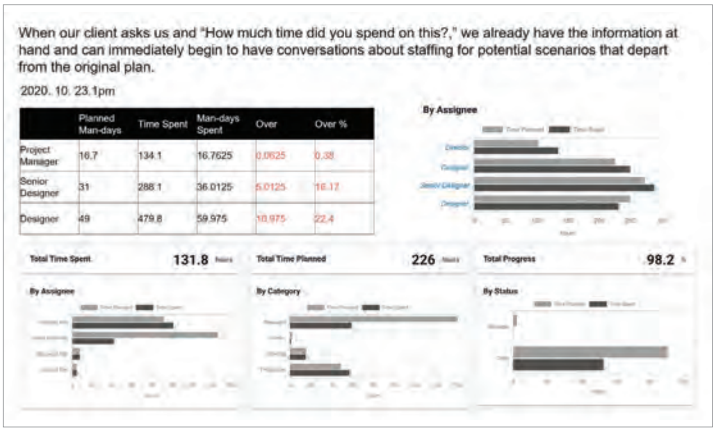


<Figure 5> Processes & Platforms 3



<Figure 6> Processes & Platforms 4

from errors in modelling, errors in model organisation, or errors in the information attached to model objects. In Figure 5, a wing of the Inlet Works building, which is supposed to be constructed in a future construction phase, has been erroneously attributed as a current phase of works, causing overlaps with existing buildings on site. With the many buildings and equipment of this wastewater treatment facility, as with any project that involves a campus of buildings, the accurate management of each building's project base point is critical to the correct placement of the building on site and to the alignment between the civil and structure works and the MEP works. In Figure 6, the architecture BIM model's base point is misaligned with the base point of the structure model causing the doors and windows to erroneously clash with the structural openings. These and other types of quality control issues need to be continuously identified and corrected promptly to prevent the ongoing BIM processes from being derailed.



<Figure 6-2> Wyzrs

Internal project management tools

Having an effective collaboration platform is crucial to the management of any team, especially a team whose members may be working variously at the construction site, the site office, the company office, or, increasingly, from home. As an example, the Independent BIM Consultants on this project selected a cloud-based project task management tool, Wyzrs, in order to define and manage progress on each team member's tasks. Start and finish dates, current status, category, person-in-charge, time spent for each task was recorded and analysed in order to optimise workable tasks, reassign any tasks that need to be backlogged or delegated, identify constraints to tasks, and to mark off completed tasks 〈Figure 6-2〉. Moreover, with the project management data recorded and available for analysis, the Independent BIM Consultant was able to provide a higher level of accountability to their client when discussing current staffing levels and projected delivery dates of tasks. When current tasks begin to deviate from planned tasks, the Independent BIM Consultant was able to engage in more informative and proactive conversations with the client about staffing scenarios, to mitigate unforeseen departures from the project's original plan.

Processes for BIM quality control

With the task of coordinating the BIM works

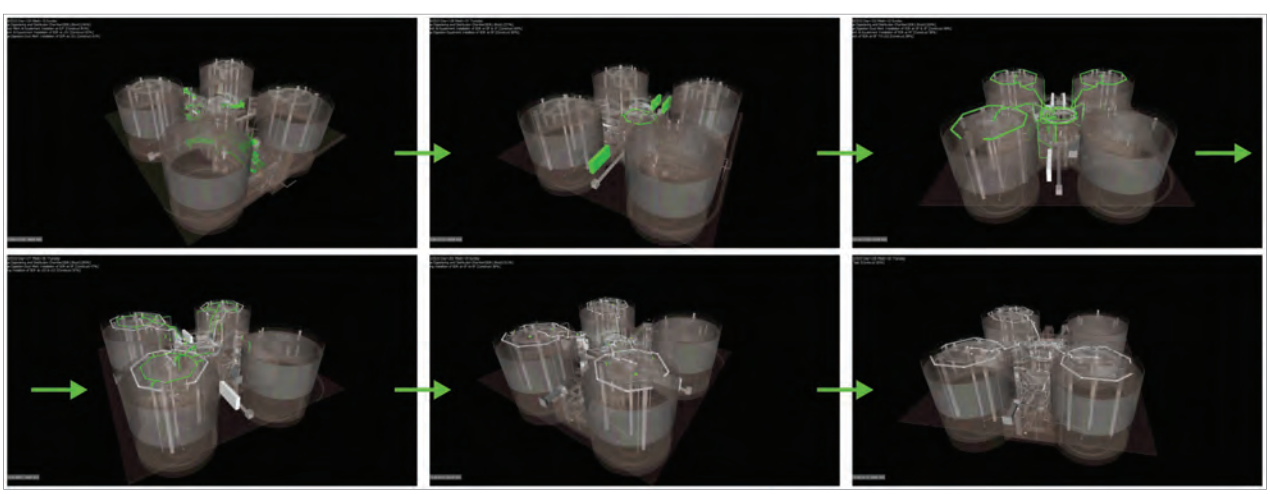
<Figure 7> BIM QC

<Figure 8> Issues

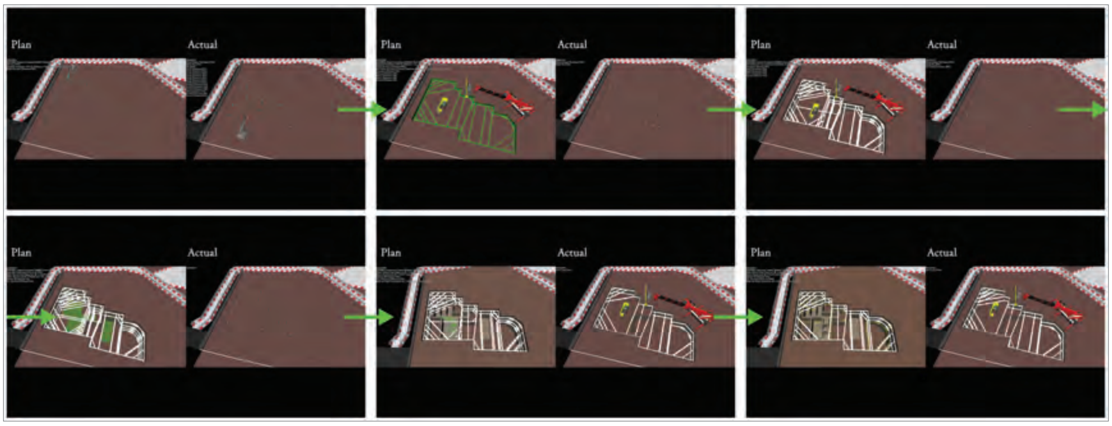
of four main contractors, the Independent BIM Consultant conducts Inter–contract Task Group (ICTG) BIM meetings and BIM Coordination meetings up to several times a week. In those meetings, coordination and quality control (QC) issues that have been identified in the BIM models and related documents are reviewed and resolved. In preparation for these meetings, a BIM QC Report is created which documents each instance of clashing, coordination issue, model compliance, document compliance, and timeliness of BIM submittals. Figure 7 is an example from the BIM QC Report showing that the positioning of a temporary backup tank has caused a clash with a staircase and railing and how the repositioning of the tank during the ICTG meeting has solved the clash. It is the responsibility of the main contractors' BIM teams to follow up on the BIM QC items until they are resolved and the responsibility of the Independent BIM Consultant to monitor the process. These BIM QC Reports, along with all model files and BIM–related files, are uploaded and shared on a regular basis on the project's Common Data Environment which, in this case, is Autodesk's BIM 360.

The need for a Common Data Environment (CDE)

For a project that contains over forty buildings and equipment systems located on a site that is more than thirteen hectares, having a CDE for the storage, management, and collaboration of files, records, mark–ups, comments, and issues is indispensable. In the case of the wastewater treatment facilities, the CDE is Autodesk's BIM 360. From the project inception in April 2020 to January 2021, the monthly usage of the CDE has increased from 1,624 activities to 4,365. Design clashes are documented, within in the BIM 360, using one of its functionalities called "Issues." In Figure 8, an Issue has been recorded where a column is clashing with a staircase at the Chemical System building. The title, number, and description of the Issue is created along with a 3D marker that is placed at the issue's location in the model which is viewed through the model viewer



<Figure 9> SludgeDigester4D1–01



<Figure 10> PlanvsActual 4D2

in BIM 360. The Issue is assigned to an individual in the CDE and tracked until it is resolved and closed out.

Tools for 4D simulations

4D construction simulations, which simulate the activities related to the BIM model's 3D objects over the course of time, are valuable on all projects. Figure 9 shows a sequence of images taken from the 4D construction simulation video file which demonstrates the sequence of MEP installation into the sludge digester building of the project. In this project, the software tool to produce the 4D simulations is Navisworks TimeLiner. Besides using 4D simulations to analyse construction sequence, they can also be used to illustrate differences between the planned construction and the actual progress by having side-by-side simulations of planned vs actual. In Figure 10, we can see from the 4D simulation that the actual progress, on the right side of each still image, is beginning to fall behind the planned construction on the left.

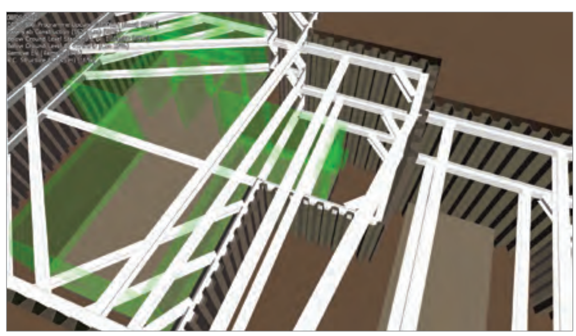
4D construction simulations are also useful to develop and visualise construction methodology. Figure 11 shows the method of installation of the sheet piling, excavation, and lateral support for the foundation works for one of the buildings. Furthermore, 4D simulations are, not only useful for analysing the new construction, but also relevant to visualising demolition work on existing structures. Shown in red in Figure 12, is the demolition of two existing primary sedimentation tanks, before the construction of the membrane facilities building.

Visualisations for better understanding

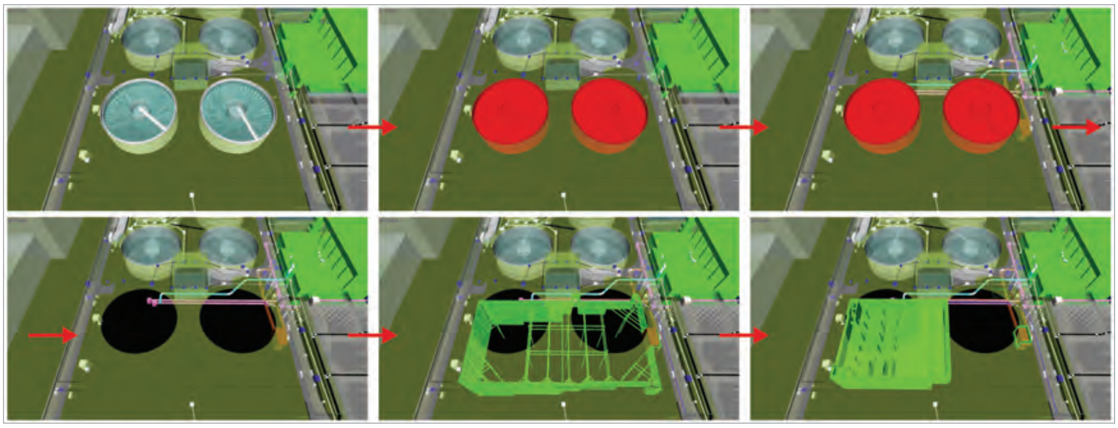
Graphical 3D visualisations are a fundamentally helpful way to promote a thorough understanding of the details of a project and ensure that clear communication takes place between the project participants. Flythroughs of the wastewater treatment project's work-in-progress models which combine the models of all four main contractors are created and periodically updated by the Independent BIM Consultant. Enscape, a visualisation tool that integrates with Autodesk's Revit, is used to create these flythroughs which are presented to the owner on a monthly basis. These flythroughs (Figure 13) are not only useful in presenting the progress of the BIM works but also in highlighting specific issues which may have escaped attention in 2D documentation and which can then be further analysed with greater care in 3D.

Benefits of the processes and platforms

In order to service the BIM processes that have been engaged on the project, the Independent BIM Consultant is using Wyzrs to manage tasks and deliverables within their team and to facilitate



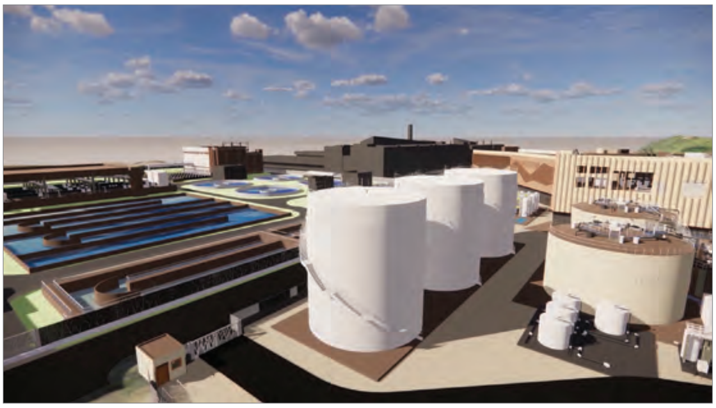
<Figure 11> ELSmethods



<Figure 12> Demolition

the collaboration between team members, especially when that collaboration – due to the coronavirus – is taking place remotely. This has resulted in better team management, greater accountability of time spent on contractual deliverables, and improvements in their on-time submission. Enscape is used to create the visualisations to help participants understand the BIM-related works progress and the more complicated areas of the project, resulting in improved communications and comprehension.

The main contractors are predominantly using Revit for their modelling; however, the underground utilities are modelled in Civil 3D. The models are federated by the Independent BIM Consultant using Navisworks on which they also conduct quality and compliance checking. A better understanding of the construction sequencing and complications in construction methods is achieved through Navisworks TimeLiner's 4D simulations; while, clashes and issues are documented and tracked in BIM 360, which is also the common data environment of the project, where all BIM-related files are stored and shared.



<Figure 13> flythrough

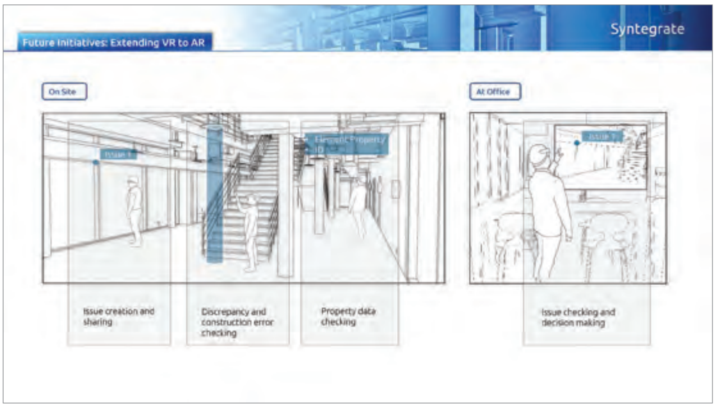
Future project management initiatives

One of the technologies that has been approved and is in the process of procurement is 3D Virtual Reality (VR). By combining 3D VR and the BIM model and extending their use to Augmented Reality (AR), we can superimpose the virtual model into the real world, during site inspections, to check for discrepancies with the BIM or out of tolerance construction. We can then create, mark-up, and share these issues, in real time, to colleagues for follow up. We can also access equipment information, such as part number, manufacturer, or maintenance schedule for a piece of installed or to be installed MEP, when we are at site, via a heads-up display. And when we are back in the site or company office, our colleagues can further analyse the issues by watching the AR recorded footage from the site inspection overlayed with the BIM (Figure 14).

Another technology that is to be implemented is RFID, or Radio Frequency Identification, tagging. This will be used during the construction phase and transitioned for use for the future operations phase. During construction, materials and equipment will be tagged at the factory and tracked during fabrication and transportation, from there, to site storage, as it begins installation, at the end of construction, and at the start and end of the commissioning process. The same tag will then be used to monitor equipment maintenance or performance during operations. Throughout this RFID tracking process, the actual equipment will be linked to its virtual twin in

the BIM model so that relevant data, stored in the RFID tag database, can be visualised in the BIM.
Another technology that is being explored as it has become a requirement by the Hong Kong government, on all public projects exceeding HKD 300 million, is the use of Digital Works Supervision Systems (DWSS). DWSS is the term given to a secure digital record-keeping of inspection and survey documentation, site diary logs, site safety inspection records, cleaning inspection checklists, and information on labourers deployed on site. Government requirements also stipulate that the technology be deployed on mobile devices and be linked to the BIM model. Potential commercial products that are being considered are Novade, and Autodesk's Plan Grid. Additionally, the secure validation and ledger documentation of these site records, via the use of blockchain technology, is also being explored.

Significant advances have been made in the last decade in BIM-related project management technologies that can improve accuracy of the design, efficiency of the project management during construction, quality of the final build, and safety of workers on site. However, as is the case in the above-mentioned waste water treatment facilities, these technologies must be accompanied by a rigorous set of best practices, project participants who are committed to leveraging these tools, and a high-level mandate, in order for the promised returns to be realised.



<Figure 14> AR

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라이오넬은 신테그레이트의 설립자 및 디렉터로서 2014년부터 수준 높은 BIM(Building Information Modeling) 및 파사드 (façade, 건축입면) 서비스를 제공해왔다. 라이오넬은 신테그레이트가 위치한 한국, 일본, 홍콩 뿐만 아니라 미국, 프랑스, 아랍에미레이트, 카타르 등지에서 20여년 동안의 BIM 분야 경험을 가지고 있다.

Lionel is a founder and director at Syntegrate, which was established at the beginning of 2014 in order to provide the next generation of Building Information Modelling and Facade Design services to the architecture and construction community. He has worked in the BIM industry for twelve years at locations including the USA, France, the UAE, Qatar, Korea, Japan, and Hong Kong, where he is now based.