Magazine for Construction Management and Engineering

INTERVISIE

December 2021 | Number 31 | Volume 19

<Subject>
Digitalization
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EDITORIAL

Dear !intervisiE reader,

The last two years were undoubtedly different from previous years. Covid measures have impacted our lives in many forms, from the way we work to the way we live. The 18th board (both the first and second semester boards) mainly operated during some form of lockdown or restrictions. Our focus shifted from organizing events that were relevant to the industry, to figuring out which events are allowed and keeping up morale. Some students enjoyed working and studying from home. Not having to travel every other day allowed some of us to focus on other activities and obligations next to our studies. Others couldn't wait for on-campus activities to restart again.

Last year's developments inspired us to choose a topic that seems inevitable and urgent, but also logical and relevant. While the pandemic forced us to resort to digital means of communication, it also inspired us to think beyond our daily routine. This made us wonder how far the industry is with digitizing its work process and what questions have arisen as a result of this digitization.

The first half of 2021 forced us to focus on the essential duties of the board, including the new installment of the 18th board (2nd semester). Yet we hope that this concise version will inspire us to focus on what the digital world has to offer and how we can best employ it in our field. In this edition of !intervisiE we will highlight the activities of the 18th Board. Susan Donders will tell her story about working from home. BIM-Connected will explore the challenges related to human-computer interactions. Witteveen+Bos will explain the connection between digital design and manufacturing. Ekaterina Petrova and Pieter Pauwels will explore the Web of Data. Siddharth Panjwani will show the possibilities of circular building through digital material procurement and lastly, we would like to introduce the 19th board of ofCoUrsE! to you.

We hope that you will enjoy reading this year's !intervisiE!

Sincerely,

Sietse Touker, Chief editor

Sara Guendouz, Editor

COLOPHON

General
!intervisiE is a publication of-of CoUrsE!, the study association of the master track Construction Management & Engineering (CME) at the Eindhoven University of Technology.

Edition
This is the 31st edition of the magazine

Sources
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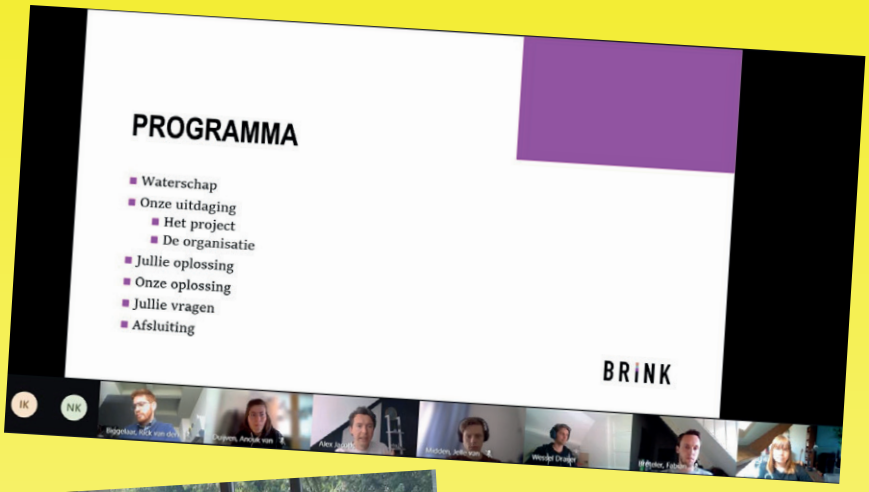
IN PREVIEW



EDITION NR. 31

CONTENT

ABOUT CME

Master of Science (MSc) in Construction Management and Engineering (CME) is a two-year master's programme taught in English. It addresses the increasing need for reforms within the architectural, engineering and construction (AEC) industry. The CME program is a 4TU program given at TU Eindhoven, TU Delft, and TU Twente and does not include the Wageningen University of Research. ("Education | of CoUrsE!," n.d.)

CME at TU/e

An interdepartmental program between the Built Environment (BE) and Industrial Engineering & Innovation Sciences (IE&IS) departments, the CME program possess a distinctive research-driven and project-oriented approach to education. You will use a combination of urban/building sciences and management and innovation sciences to develop solutions for smart urban development.

Focus at TU/e

Our Construction Management and Engineering program anticipates that change by exploring the area between 'construction engineering' and 'scientific management and economics'. It focuses on the management and implementation of urban development processes with an emphasis on smart cities. In particular, it looks at:

City Information Management (CIM): considering the emerging field of urban informatics (including geospatial data, sensor data, 3D city data, etc.), creating virtual representations of cities with real-time connections to the physical world and its inhabitants, catering to various stakeholders such as municipalities, citizens, architects, urban planners, transport engineers, and construction companies, to make informed decisions using urban analytics in the context of smart cities.

Building Information Management (BIM): handling and managing building information throughout the building life cycle, improving the Architecture, Engineering, Construction, operation, and demolishment process, using both static data (including building models, point clouds) and dynamic data (including sensor data, IoT) allowing for the creation of digital twins of buildings and its occupants, and real-time data processing employing AI technology in the context of smart buildings.

Reasons to study CME

The scientific and social relevance of the CME program is beyond doubt and offers long-lasting career opportunities for CME graduates of the TU/e. CME graduates find jobs at: engineering consultancy offices, governmental institutes, start-ups, and contractors. This applies to all students, irrespective where they come from, because the CME program has a very international scope. These prospects are evidenced by the CME alumni association.

CME at TU/e has a unique position, not only in terms of its existence in the Netherlands, but also in terms of its scientific embedding at TU/e. It involves a cooperation between two domains of science: Built Environment and Industrial Engineering & Innovation Sciences.

Research

The CME program has a clear scientific signature: strong involvement with research activities, organized and captured within two research schools: DDSS and Beta. CME students can be involved in state-of-the-art research projects, often funded from EU and national research funds or from industry, and learn from top researchers in the field.

References

Master Construction Management and Engineering. Retrieved September 21, 2021, from https://www.tue.nl/en/education/graduate-school/master-construction-management-and-engineering/

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

THE 18TH BOARD OF – of CoUrsE!

The year to remember!

Unlike other years, the 18th (and a half) board only came together in February. Both the first and the second installation of the board faced many new challenges related to the pandemic. We all had to adapt to working from home and limited face-to-face interactions, a challenge for both the board and all of the students. Regardless, the year has been rewarding and we believe that these challenges allowed us as an organization to enrich and build upon the foundations developed in years past.

My name is Jelle van Midden and I am a second year CME master student at the TU/e. I became part of the board during the second instantiation in February 2021, and I took upon the role of chairperson. I have been working together with both members of the previous and current board and I am glad to say that many have chosen to stay and join the next board. Both the first 18th board: Ece Karabinar (Chairperson & Commissioner of Education), Ellen van den Bersselaar (Commissioner of Public Relations), and Ramin Khoshnevisansari (Secretary & Treasurer), and the current 18th board: Jelle van Midden (Chairperson), Ece Karabinar (Commissioner of Education), Susan Donders (Commissioner of Public Relations), Fabian Breteler (Treasurer), Sietse Touker (Commissioner of Communications and !IntervisiE), Sara Guendouz & Ellen van den Bersselaar (open functions), have done great work this last year by keeping the spirit high and the energy flowing.

Our aim for next year is to strengthen the relationship between students, academics and the industry in a more fun and proactive way! Feel free to reach out to us if you feel inspired to help us with organizing and participating in activities. Together we will make this year a blast!

We hope you enjoy this year's version of !IntervisiE. Follow our social media channels to receive the latest updates on fun activities and more! Stay safe and healthy.

Jelle van Midden
Chairperson
19th board of CoUrsE!

EVENTS OF THE 18TH BOARD

This year was very different from what we are used to. Due to the second lockdown many events that we wanted to organize unfortunately couldn't be organized. This forced our board to rethink how we organize events. The emphasis was on online courses and lectures, as well as an online pubquiz and beer tasting. Fortunately, we were able to host two legendary barbecues last year.

Below you will find a snapshot of the different types of activities we organized for students this year.

Legendary BBQ 2020

2

IFC online lecture

3

Pubquiz

4

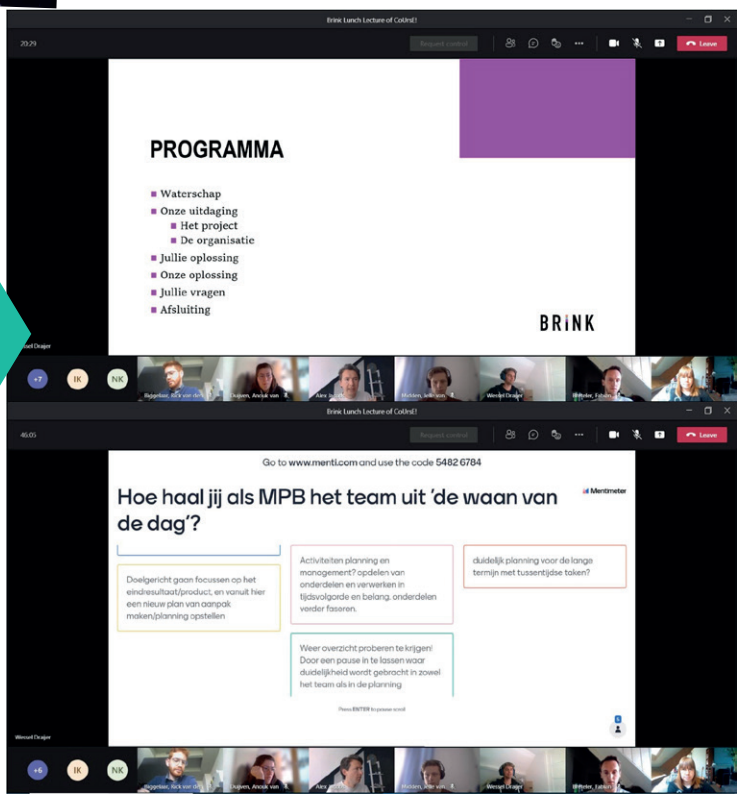
YER workshop

5

Online Python course

BRINK lunch lecture

6



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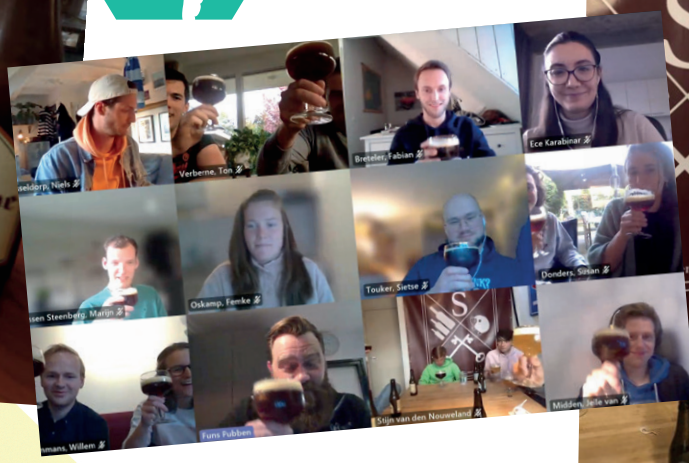

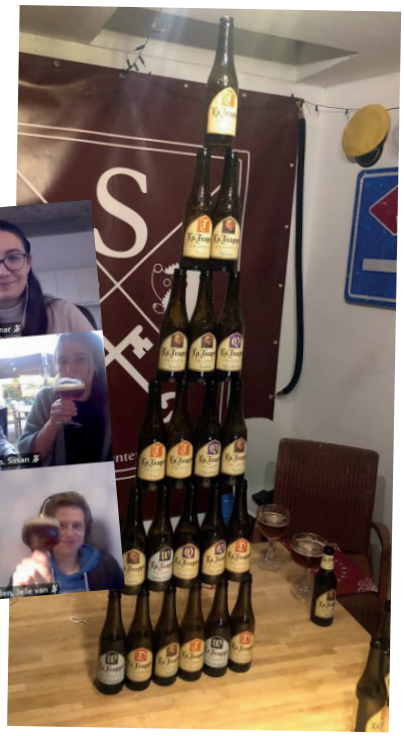

La Trappe beer tasting

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Oxand lunchlecture

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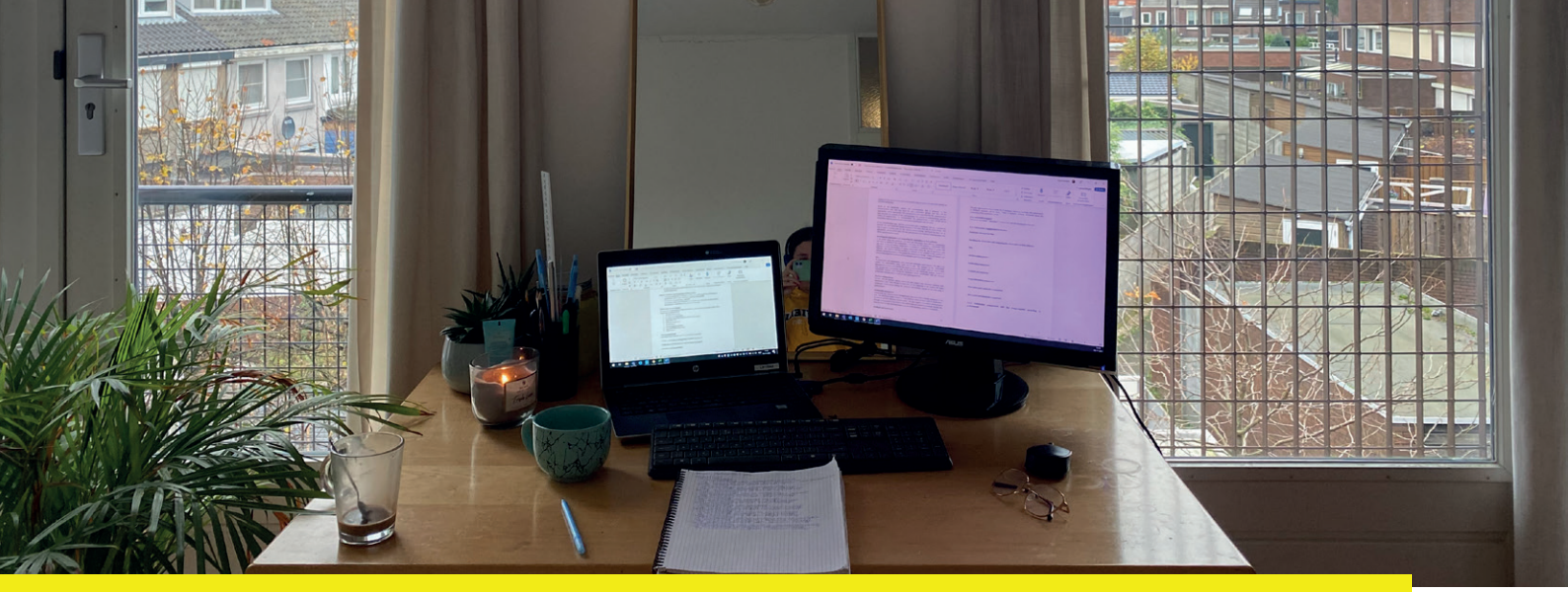
Legendary BBQ 2021



Working from home: Susan Donders

Hi Everyone! My name is Susan and I am 23 years old. Currently I am in my last quartile of the study Construction Management and Engineering doing my graduation project in improving the stakeholder engagement of complex projects under the new 'Omgevingswet'. For of CoUrsE! I am the commissioner of public relations, this means that I recruit new possible companies and plan educational activities with our sponsors. The last 2 years I have had to work, study, attend class from my small room in Tilburg.

What activities did you have that required you to work from home?

In these 2 years I have changed jobs to a position more suitable and adjacent to the construction field. In March 2020 we went into a lockdown, at which point I was working as a waitress in a restaurant. Due to the lockdown, I had to quit this job and decided to help my dad out at his company. This was however not what I wanted to do, so I decided to do an open job application at a construction company. I began working there in the summer of 2020. I work there part-time, two days a week, as a "work student" and juggle this with my study.

As a board member, at the beginning of lockdown, I was just helping out with the activities, to later take over the role of PR. We organized beer tastings, pub quizzes and some lunch lectures. In 2021 I took over the role of PR in which I would call with companies and explore opportunities for lunch lectures.

How did your average day look like during lockdown?

An average day for me started as normal as possible. Even though I was doing everything from home I tried to keep a rhythm in the way I spent my days. Most days I would wake up at 6:30 or 7:00 so that I could slowly wake up and set up everything for work that day. My first meetings for work started at 8:00. If it was a day devoted to studying I would also wake up at around 7:00 so that I was able to start studying at 8:30.

A day of working meant that I would work until 17:30. During the day I would take breaks by going for walks in the park close to my home, or having lunch with my roommates. On the days that I would have work, I had to catch up on studying in the evenings. My days were a lot more relaxing when I only had to study. I would watch the lectures and work on assignments. With most courses that I followed group work was required, so often I would meet with groupmates to work on the courses.

In the evenings, my roommates and I would have dinner together at around 18:30. After dinner, I would pick up studying again at around 21:00 and work until midnight. On weekends I went out mountain biking or road cycling as this was one of the only things still allowed during lockdown.

What advantages and disadvantages did you experience whilst working from home?

A major advantage I would say is the amount of time I saved by not having to travel to work and university every day. The lockdown made the house a lot closer. We often had coffee breaks together (which most of the time would result in forgetting about the time and having to rush back into work). In the evenings we would often wind down together by doing games and watching a lot of movies.

One of the things that I struggled with while working from home was the decrease in movement. Before lockdown having to go into work and university forced me to be a lot more active. Whereas during lockdown I had to force myself to go out for a walk or do workouts from home. Trips to the supermarket became a gift to me every day.

Another big struggle was the closeness of my bed when working from home. I live in a student home, which means my room is basically my office, bedroom and garbage dump ;). To overcome the urge of sitting in bed all of the time, I would make my bed before starting the day. I also made sure nothing was on the ground or on my desk this way I maintained productivity.

My three tips for working from home

- Make up your bed every morning, this way you will not jump back in bed that quickly.

- Go outside during your lunch breaks.

- Call friends to study together via Teams

Susan Donders
Commissioner of PR for ofCoUrsE!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COMMUNICATION BETWEEN HUMANS AND COMPUTERS

The importance of machine readble data is not yet self evident within the digital transition.

Bob van Thiel MSc | BIM-Connected | July 2021

Innovation and digitalization is hot in the Dutch construction industry. Besides BIM you hear keywords such as 'predictive maintenance' and 'artificial intelligence' (AI). These words have a high wow-factor! Researches and master theses about these subjects are frequent these days. However, how are organizations and project users dealing with these upcoming technologies? Is the time right to talk about using predictive maintenance within construction firms? This article provides a small piece of insight in the balance between human and computer / technology in practice.

Digitalization in our industry is important because of the large amount of data in projects and assets. Asset owners especially want to have a clear view of the current state of their assets. Think of ProRail: owner of railways, Rijkswaterstaat: owner of highways and engineering structures such as bridges and TenneT: owner of high voltage lines.

The computer plays an important role in this transition and in 'the new way of working'. Work can be done faster, smarter and more efficiently through the use of software and data. However, when using and implementing this technology, there is still a notable gap in knowledge and application. Practice is often less predictable than is explained in theory. One reason for the continued viscosity of this process is the imbalance between the person/user and the technology.

Planes don't fly like birds

Technological innovation does not inherently provide the support for a faster, more efficient workflow. It is not the way that AI solves this, in other words, that computers will understand us as humans so that they, the computers, solve the problems. We have to ask ourselves for what purpose do we want to use intelligent machines and technology. We cannot think that BIM and/or the digital transition makes our work easier, as we have been doing it for years. Digital transition is also about moving, taking along, learning and the adaptation and acceptance of people.

Practical example

A small example: recording the year of construction of a building. Why retain this data? For insight and inference information. For example: which/how many buildings, owned by the Dutch state, were built before 1960? How does a computer help me with this? By automatically requesting my data (executing queries). But what should we do then? Fill in the year of construction correctly, in an unambiguous way!

To get an automated answer to the question the user will have to make the data readable for the computer:
- What is the data type?
- What is the format?

If you disregard this, you have a high chance of a jumble of values: 1959, ? (probably 1961), see delivery document X, unknown, '55, (mid) 1970s. Ask yourself whether the computer can help you with the question asked. Humans are able to do and understand their work themselves, but a computer needs a command to complete a task.

Importance of adaptation

From BIM-Connected's point of view, the digital transition is a balance between humans, technology and processes. Technology facilitates your processes and humans have to work with computers and technology. Humans and computers must work together from their own expertise to create better quality. Better quality will lead to smarter and more efficient handling of data.

I see a future, especially for CME graduates, where young engineers bridge the gap between users and machines.

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BIM CONNECTED

DIGITALIZATION IN THE CONSTRUCTION INDUSTRY

WITTEVEEN + BOS RAADGEVENDE INGENIEURS B.V.

August 2021

Since the invention of the computer, digitalization has increasingly shaped industry. The construction industry in particular has been slow in adapting to new possibilities offered by technological advancements. A study consisting of 22 industries conducted by Harvard Business Review in 2016 puts the construction industry at the second lowest place, just above agriculture and hunting. For a successful digitalization, an organization needs to a) digitalize its assets, such as networks and computers, b) use digital technology for engagement with all parties in their process chain and c) digitalize their workforce through education and digital tools. Why is it so difficult for the construction industry to keep up? And what are the main drivers of change?

The processes in urban and building development are getting increasingly complex. Projects need to answer to societal transitions towards circularity, carbon neutrality, biodiversity, among others. More domains and disciplines are involved and the need for an integral approach is ever more crucial. Also, stakeholders with different interests want to have their say in the decision-making process. New legal frameworks such as the Dutch Omgevingswet make these process requirements mandatory.

The expectations of clients and end users are also evolving. Within urban planning, for example, developers want to create healthy living environments, which leads to requirements exceeding the traditional functional demands. Clients want to be involved during the process and monitor how projects are progressing. There is bigger demand for monitoring quantitative Key Performance Indicators in order to track the implementation of goals in

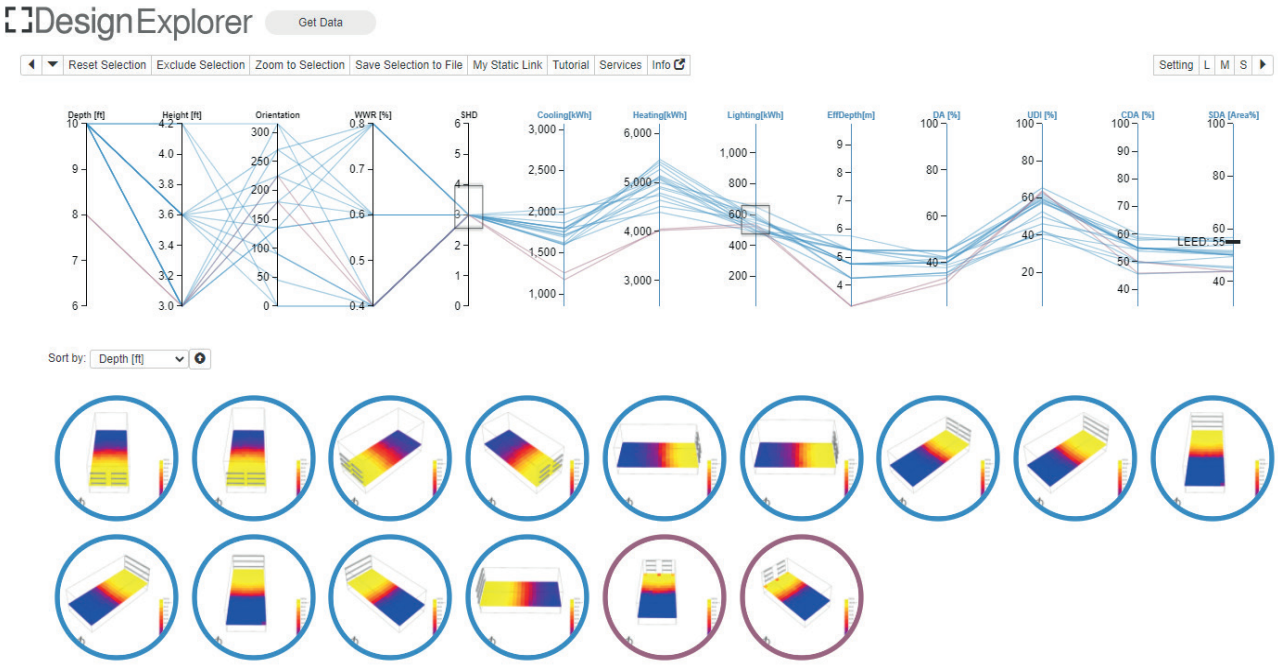

Figure 1 Design Explorer for project monitoring

the project. Some examples of these indicators are heat-stress levels, water drainage capacity, energy demand or building costs. Furthermore, clients do not prefer a single-end solution but rather a "solution space" with a variety of options that are easily comparable. Such a solution space offers clients more control in the decision-making process.

Lastly, new technological advancements such as IoT, VR/AR, 3D printing or Cloud based computing create more ways to digitalize the construction industry. The transition of these technologies, from mere novelties and prototypes to full integration and adoption in project processes does come with challenges.

These trends have an impact on our services in urban planning and construction. At Witteveen+Bos we see the opportunities of digitalization and have made big steps in our organization to exploit them. What steps have we taken?

Smart and Healthy Cities

The Smart+Healthy City team within Witteveen+Bos advises developers and cities in creating healthy living environments. A healthy city is a wide concept involving many different disciplines such as, active mobility, urban climate, healthy building, child friendly spaces, air, and sound to name a few.

Witteveen+Bos offers evidence-based advice. This means that our advice is underpinned by data-driven analysis and models. The outcomes of these analyses are quantitative and can easily be combined and used to evaluate progress in relation to project goals. This way we can address different disciplines integrally and help make the decision process more objective.

For example, for the redevelopment of a shopping mall in Alphen aan de Rijn, where a new tower was introduced, we have used a Computational Fluid Dynamics model to simulate the effect the new development would have on wind flows. This allowed us to give objective advice on wind stress levels on ground level.

Digital building construction

The Digital Construction team within Witteveen+Bos works on creating the connection between digital design & engineering with digital manufacturing and construction. In traditional construction projects much of the work of the engineers has changed over the last decades and has become digital with i.e., the use of Building Information Modelling (BIM) but the construction process itself has not changed much and is still labor intensive. We believe that by designing structures that can be built with robots, the productivity of the construction industry increases significantly, and the environmental footprint of the industry can decrease dramatically, due to material and process optimization.

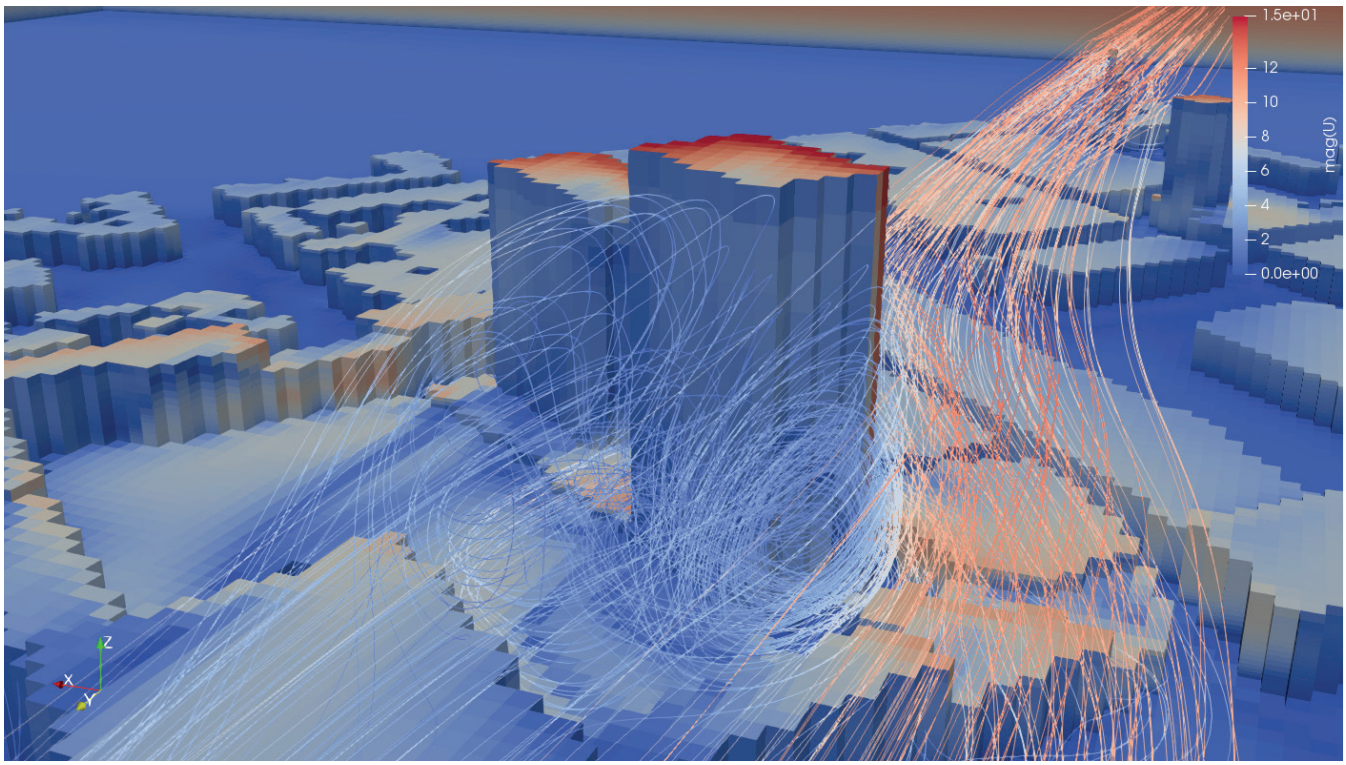

Figure 2 Computational Fluid Dynamics Model shopping mall

Figure 3 3D printed house Project Milestone in Eindhoven

Project Milestone in Eindhoven is an example of digital construction in practice. For the design and the engineering Witteveen+Bos created a parametric model. The outputs of this model are inter alia the rapid code that was produced by the giant 3D concrete printer that could be used to print the elements of the Milestone house. The final house of project Milestone will be printed on-site. Besides printing the structure, the robot will also perform other tasks such as lifting, mechanical, electrical and plumbing installation (MEP installation) and finishing - showcasing the future of digital construction.

Digitalization is an ongoing process. The construction industry is making big steps in digitalizing its processes. However, improvement of the industry's IT infrastructure, chain management, education of staff and software development is needed to accelerate its digitalization.

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ON THE MEANING OF ALL THINGS BUILT

Or how the Web changes the way we design, build, and operate the built environment

EKATERINA PETROVA & PIETER PAUWELS

August 2021

From a flat, boring world devoid of meaning to a machine-interpretable Web of Data

In 1994, the creator of the Web, Tim Berners-Lee, described his creation as "a flat, boring world devoid of meaning" for machines (Berners-Lee, 1994). What might have been a controversial statement at the time originated in the fact that documents on the World Wide Web describe existing things, objects, imaginary concepts, and the relationships between them all have meaning (semantics). And while the meaning of these documents and the significance of the links between them were understandable by humans, very little from this exciting new world was interpretable by machines.

What could we then do to help machines understand? A remedy would be adding semantics to the Web, which required making machine-readable representations possible and creating relationships that made sense to machines. Why was that significant? As stated by Tim Berners-Lee, only when this extra level of semantics is present would we be able to fully leverage computer power that can help us exploit information to a greater extent than our own reading (Berners-Lee, 1994). This vision manifested itself into a Semantic Web Road Map in 1998 and, finally, into the seminal article featured in the Scientific American, "The Semantic Web: A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities" (Berners-Lee et al., 2001).

Today, 20 years later, the Web has become one of the most influential threads of our life. And even though the vision for the Semantic Web was to describe things, people, concepts, and the relationships between them in a clear and an unambiguous manner so that both computers and humans can interpret and use them, the term itself is still quite ambiguous. What is it, how does it work, what can it do for us and, more importantly, what can it do for the built environment?

The nuts and the bolts

Initially a web of documents, the World Wide Web has evolved into what we nowadays refer to as the "Web of Data" (Linked Open Data (LOD) cloud) (Bizer et al., 2009).

This evolution was enabled by the Linked Data best practices, which help lower the barriers to publishing, sharing, and accessing information on the Web. Linked Data as a term was coined by Berners-Lee in 2006, who introduced a set of rules for publishing data on the Web, so it becomes a single global dataspace. The best practices include (1) Using Unique Resource Identifiers (URIs) as names for things on the Web (a kind of unique IDs for things); (2) Using HTTP URIs so people can look up these things on the Web; (3) Using standards (e.g., Resource Description Framework (RDF), SPARQL query language, etc.) to provide useful information when someone looks up a particular URI; (4) Including links to other URIs so people can discover even more things (Berners-Lee, 2006). These best practices form the foundation of the so-called 5-star open data, which implies defining data according to the RDF data model and interlinking it with other RDF datasets, thereby creating the LOD cloud (Figure 1). Currently, there are more than 80 million pages with semantic, machine-interpretable metadata according to the Schema.org standard and the LOD cloud contains 1301 datasets with 16283 links (as of May 2021).

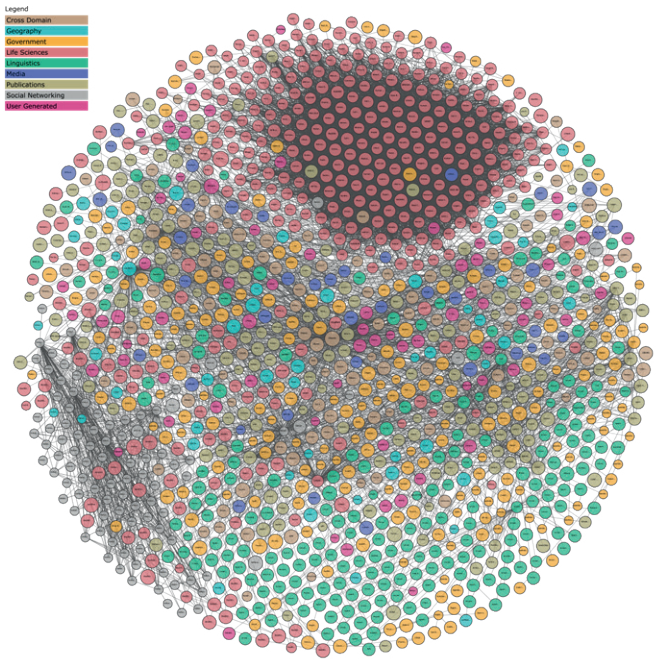

Figure 1 The Linked Open Data Cloud from lod-cloud.net. The image shows datasets that have been published in the Linked Data format.

In terms of defining data, the RDF data model encodes data in subject-predicate-object triples that form graphs (Figure 2).

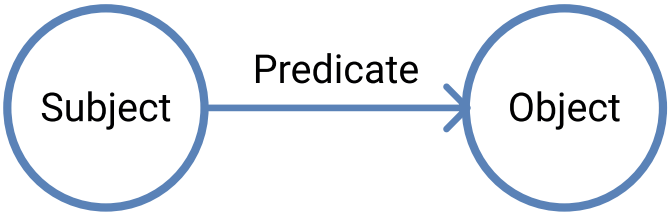

Figure 2 RDF triple comprising (subject, predicate, object)

An RDF triple is a statement about semantic data that defines a way to represent things and their relationships. The predicate is the link that relates the subject to the object. In other words, the subject-predicate-object expression can take any subject and connect it to any other object via the predicate to show the type of relationship that exists between the subject and the object (e.g., "Bob likes doughnuts"). Therefore, the Web of Data is a composition of graphs (example in Figure 3), which rely on the triple structure to describe information with uniform syntax and semantics. As a result, the information becomes reusable by both humans and machines.

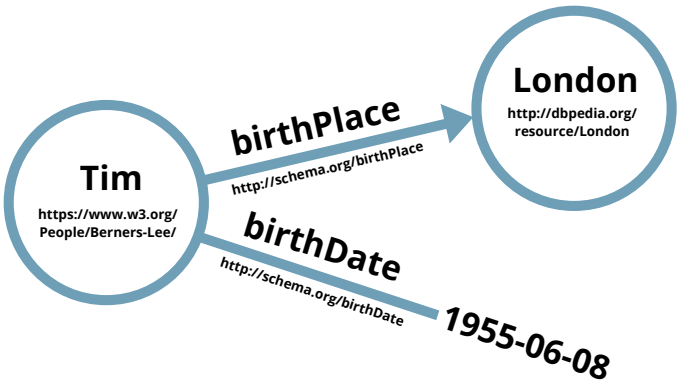

Figure 3 An example of a semantic graph describing a person, a place, and a date, and the relationships between them

The Web of Data relies on ontologies (vocabularies) to give meaning to things and relations. Ontologies are "formal, explicit specifications of shared conceptualizations" (Gruber, 1993). They provide the meaning (semantics) to the data and allow it to be queried using query languages (e.g., SPARQL, SWRL, etc.). All these building blocks constitute the Semantic Web envisioned by Berners-Lee (2001) as "an environment where software agents roaming from page to page can readily carry out sophisticated tasks for users". This fascinating vision for a Web of Data that is easily interpretable by both humans and machines has evolved significantly both as a research field and a technology stack. As a result, it is also seeing a massive industry interest, and several of its embodiments are already enjoying mainstream adoption. For example, millions of web pages are tagged with semantic annotations using Schema.org to provide a better search experience on the Web. Furthermore, the LOD cloud contains interlinked datasets published in a decentralized manner (without centralized control) across thousands of servers.

The more recent Knowledge Graph (KG) concept has also sparked major interest. It brings the Semantic Web vision to organizations and allows them to break information silos, synergize various forms of knowledge management, use global knowledge as context for data management and uncover new information from existing relations in their data. If you have used Google, you have also used a plethora of Linked Data scattered across the Web through Google's KG. That also includes the giant RDF graph of Wikidata (a structured encyclopaedia with 100 million topics with over 10 billion properties and relationships), which is one of the sources from which Google's KG is updated.

What does it all mean for the built environment?

Throughout the last decade, the Architecture, Engineering, Construction (AEC) domain has also recognized the potential of the Web of Data and Linked Data technologies (Pauwels et al., 2017). Among the most notable efforts is transforming the Industry Foundation Classes (IFC) open data standard into a Web Ontology Language (OWL) ontology (Beetz et al., 2005; Pauwels & Terkaj, 2016). Even though that transformation makes it possible to bring building data to the Web and allows Web-based exchanges, ifcOWL mirrors the large IFC schema, which contains all possible kinds of building and civil engineering-related entities almost entirely. That resemblance makes the ifcOWL ontology complex, difficult to extend and non-modular. That means that a "pick-and-choose" approach is not possible at the application level, and the user is bound to the schema in its entirety.

Despite its shortcomings, the ifcOWL initiative also laid the foundations of the buildingSMART Linked Building Data Working Group and the W3C Linked Building Data Community Group. The groups aim for standardization of the representation and exchange of building data over the Web, thereby bringing AEC to the next level of technological advancement.

Linked Building Data

As a result of the above efforts, several other initiatives aim to define an ecosystem of smaller, modular, and extensible Linked Building Data (LBD) ontologies that do not rely that strongly on IFC but cover similar concepts. Each ontology covers parts of building data that can also be exchanged with IFC. Central here is the Building Topology Ontology (BOT), which defines essential terms such as 'Building', 'Space', and 'Element' (Rasmussen et al., 2017). Starting from the BOT ontology, alignments can be made with various ontologies covering other domains.

As a result, the construction industry can rely on a set of modular ontologies aiming for sharing and linking cross-domain data while still leaning on a standard at the core (Figure 4). Besides the BOT ontology, this set includes Building Element Ontology (BEO), Ontology for Property Management (OPM), Building Product Ontology (BPO), File Ontology for Geometry Formats (FOG), Ontology for Managing Geometry (OMG), which define properties, products, and geometry respectively.

Digital Twins

The advancement of the Internet of Things (IoT) (e.g., sensors, actuators) and reality capture devices (e.g., laser scanners, drones) also allows monitoring and collecting operational data from built facilities. The large volume of collected (real-time) data is the backbone of creating Digital Twins of

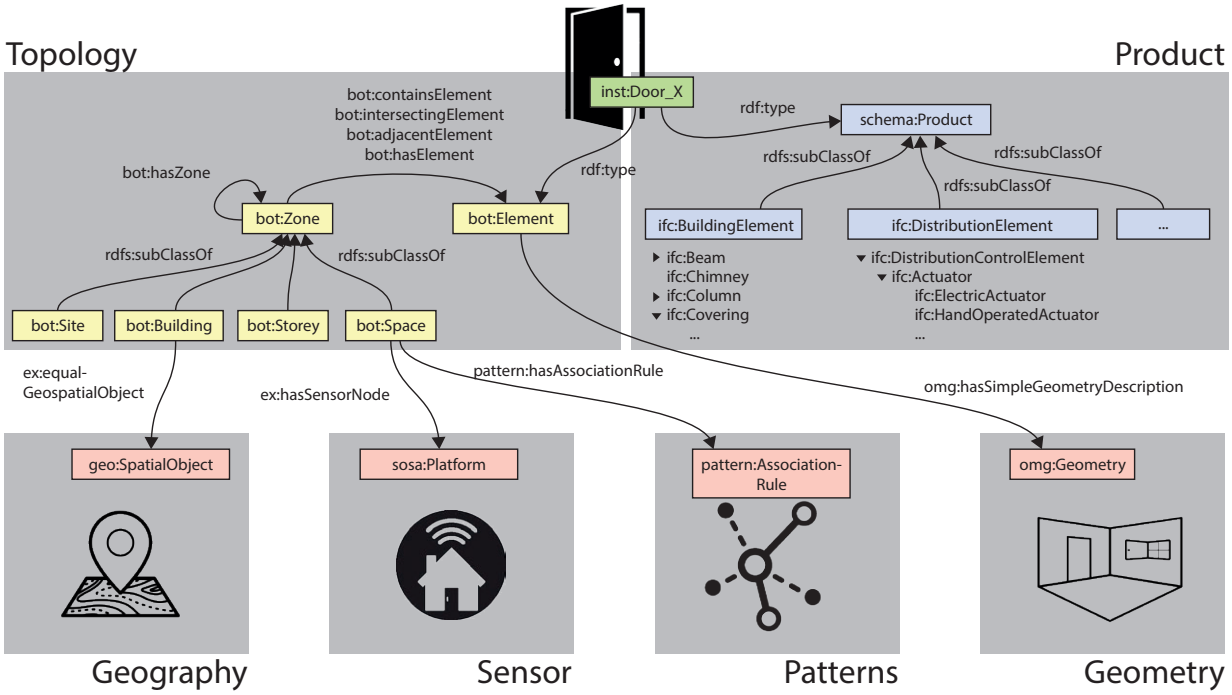

Figure 4 Conceptual overview of modules and ontologies in a Linked Building Data cloud, based on the work in the W3C Linked Building Data Community Group (Petrova et al., 2019)

physical assets. Digital Twins are associated with creating high-fidelity digital models of physical objects to simulate their real-world behaviour and provide feedback (Grieves, 2014). The aim is to create a comprehensive physical and functional description of a component, product, or system and reproduce the physical assets' geometry, physical properties, behaviour, rules, etc. (Söderberg et al., 2017). Currently, the AEC sector relies primarily on file-based exchanges. Building Information Modelling (BIM) has been adopted but has not been widely applied in the operational phase. The reason is the complex nature of IFC and its predominant focus on geometry representation and limited capabilities when it comes to cross-domain data linking.

On the other hand, Digital Twins have unlocked research that targets enabling live data warehouses and allowing dynamic simulations and predictive intelligence in the built environment (Sacks et al., 2020). When it comes to semantic technologies and the operational phase of built assets, the most expressive and complete ontology-based data model that can capture the aspects of building operation is the Brick schema (Fierro, 2019). Brick is designed to represent the domain of smart buildings and focuses on Heating, Ventilation, Air Conditioning (HVAC), Lighting and Building Management Systems (BMS). As such, the ontology helps describe building systems equipment and sensor points and defines three main classes – 'Equipment', 'Location' and 'Points' (Fierro, 2019).

Recent research shows that the feasibility of Digital Twins of built assets depends significantly on the successful integration of geometric and product data from the design phase and real-time dynamic data from the operational phase. Furthermore, state-of-the-art research targets integrating robotic technologies, data analytics and Artificial Intelligence to create bi-directional Digital Twins capable of actuation. Such implementations can revolutionize the AEC sector and help improve efficiency, productivity rates, worker safety, performance and give a possibility to extract valuable insights and performance metrics from buildings and infrastructure. Moreover, the above technologies can help deploy real-time and decentralized data processing for connecting Digital Twins and real-world construction systems.

Artificial Intelligence in the built environment

The richness and exponential generation of data during the design, construction, and operation of built assets, combined with advanced technology and analytical methods, have provided the necessary prerequisites for Artificial Intelligence (AI) implementations in AEC. AI is hereby defined as a "part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit characteristics we associate with intelligence in human behaviour - understanding language, learning, reasoning, solving problems, and so on." (Barr & Feigenbaum, 1981). AI combines various fields such as machine learning, knowledge representation, ontologies, logic, Natural Language Processing (NLP), reasoning, etc., which are generally divided into two main areas: statistical methods (e.g., machine learning, data mining), which help learn patterns or regularities from data and symbolic representations (e.g., semantic technologies), which are designed to formally represent human knowledge and capture the knowledge within a given domain. The need to utilize data in an effective and meaningful way and enhance human decision-making has made knowledge a focal point in AI in AEC. Semantic representations can be used to boost machine learning approaches, enhance human decision-making, and create more intelligent systems (Petrova et al., 2019).

Semantic graphs and their ability to represent relations between buildings, locations, spaces, and other data can scale and articulate the discovered knowledge of how the existing building stock performs in a machine-readable form (Petrova,

2019). Collected building data can be combined using web technologies and various sorts of databases. The integrated data can then be used in combination with AI algorithms to provide decision support to various end users, including facility managers, construction site managers, building owners, users, and any potential stakeholder in the built environment.

Epilogue: Why the Web of Data matters for Architecture, Engineering and Construction

While the technological angle may seem mesmerising, questioning what semantics, Web technologies, Linked Data, AI, etc., can do for the future of the built environment remains healthy. In a craft-based industry such as AEC that suffers fragmentation, inefficiency, low productivity, performance issues and lack of innovation, the value of implementing semantic technologies goes beyond simply bringing the built environment up to speed with the latest technological trends and advancements.

The development and implementation of improved data handling and AI techniques in the AEC industry is a means to improve construction productivity, efficiency, liveability, quality, sustainability, and comfort of our built environment. Precisely the connectivity is what makes the Web of Data and the technologies related to it such a great solution to the challenges of knowledge management and data integration in AEC. In knowledge-intensive domains and applications such as AEC, which demand highly interconnected data with complex relationships, semantic technologies can help AEC companies obtain profound insights by linking, analysing, and exploring diverse internal and global data. Ultimately, the Web of Data will always work. Still, it is crucial to realise its potential in the built environment for accessing and integrating data across different systems without collisions. In a nutshell, formal semantics that brings explicit common meaning and validation leads to high data quality, the potential of which is unlimited for any industry.

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DIGITAL PROCUREMENT AND CIRCULARITY IN CONSTRUCTION INDUSTRY

GRADUATION PROJECT: SIDDHARTH PANJWANI

August 2021

My name is Siddharth Panjwani and I am a MSc Construction Management and Engineering student at the Technical University of Eindhoven from India. Currently, I am conducting my graduation project, which deals with material procurement on a digital platform and circularity's influence. This article gives a short description of the industry's issues regarding second-hand material procurement in a circular ecosystem and a possible ways forward.

With its "take, make, dispose of" model, the current economy is not sustainable with human demand for raw materials exceeding what our earth can supply. It is necessary to shift towards a Circular Economy (CE) in which we rethink, reuse, and renew our world's resources. With the introduction of circularity in the built environment it is essential to pay attention to not discard materials after using them only once over a building's life cycle. Since circularity is about closing loops of energy and materials, it is challenging to assess the plethora of information about the building elements used in its lifecycle and to use them wisely. In the Netherlands, the construction industry has already made some progress in transitioning towards a circular ecosystem. The construction and demolition waste (CDW) is one of the heaviest and most significant waste streams. The sector's waste in mass (kg) accumulates to about 25% to 30% of all waste generated in the EU (Oorsprong, 2018).

However, shifting to a circular economy has not been a straightforward process over the entire lifecycle as it requires substantial changes to the value chain. One possibility is second-hand material procurement, though this does come with its challenges either inherent to the procurement of materials or to reuse of second-hand materials. Some of them are as follows:

a. Salvaging materials from old buildings is difficult. Furthermore, it is challenging to justify the cost to assess the used material and upscale it against the market demand.

b. There is not much attention paid to the reuse of materials during the demolition of a building from a developer's or client perspective. Even if there is a demand from the client, concrete terms of the contract to reuse building components require a thorough analysis of building elements and their quality.

c. Furthermore, the environmental impact of a second-hand building element needs to be analysed and informed to a buyer during material procurement.

A possible solution to tackle these complications is a standardized framework to assess and justify the procurement of second-hand material.

With the advent of Industry 4.0 and technological advances, creating a digitized tool that solves the problem above is not a challenging task. Many digital platforms enable material procurement in the construction industry. However, these platforms vary based on the products they offer and the pricing approach they adopt. Some are open for all, but others are exclusive to businesses only and impose registration costs. Their pricing strategies vary based on the quality of material, market demand, logistics, transaction costs, and base price of items. However, most of them do not provide enough information on environmental impacts or material quality. This information is vital in increasing the procurement of circular materials. There are exceptions to the case when marketplaces sell bio-based products. However, purchasing second-hand materials such as concrete and steel for reuse online is not the norm.

Therefore, an exploratory study is needed to dive into the possibilities, usefulness, and necessity of a phased realization of a complete framework, accessible to

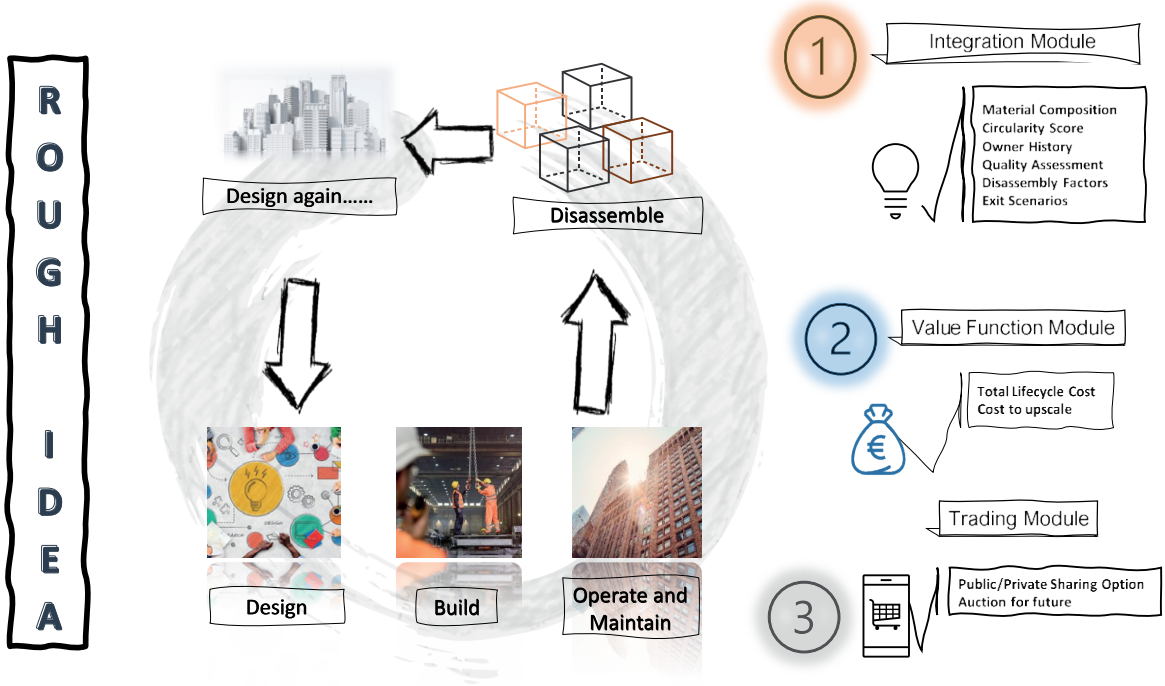

Figure 1 Proposed Framework Constituents

everyone. This framework should provide guidance about the existing stock of building materials for circular construction, their environmental impact, demand, quality, and their market value.

In my graduation project, I will assess the aforementioned issues and propose an ecosystem which caters to material procurement in a circular ecosystem. See figure 1 for a rough idea of what it will look like.

Integration Module

The BIM models from the design stage of a new building or cloud point and survey data from an existing building provide material information of building elements to formulate the material composition. In addition, this data can help develop a circularity score where the element is given a score based on how much it can be disassembled for the subsequent lifecycle use and its likely exit scenario.

Value function Module

The material information also provides a value function that includes the lifecycle cost of the first generation use of material and the cost to upscale it. In addition, the value function considers the likely price based on the quality of the element and its circularity score. These parameters are used to predict the value of the second-hand material.

Trading Module

The cost generated from the value function and the building data can be put on the trading platform, where they can be shared publicly or privately and are bid in an auction for transferring ownership after a given period. The buyers search for materials they want to bid on based on the proximity to material, the reputation of the seller in the market, performance reviews, and the predictive quality of the material required by them.

I hope this can inspire people to develop their own ideas on transforming the construction industry into a sustainable and circular industry. If you want to know more about this project or have a conversation about anything interesting, please feel free to contact me.

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Meet the 19th board

Board members

Jelle van Midden
Chairperson

Being my first year as chairperson I am excited to be part of of CoUrsE!.
I look forward to hosting fun and educational activities as an association for CME students.

Fabian Breteler
Treasurer

I'm really excited being the Treasurer of Of CoUrsE!. My finance skills were only limited before this board year, therefore I wanted to be the treasurer to improve my finance skills. Next to being the treasurer I like to help with organising activities.

Susan Donders
Commissioner of Public Relations

This year I look forward to working together with different companies to inspire CME students and help them find their passion. To work creatively in search of external parties, offering work-experience, opportunities and graduations in the field of construction.

Sara Guendouz
Secretary

I will focus this year on organizational aspects within of CoUrsE! I look forward to being of help wherever needed. Next to this, I will ensure that everyone reads their email ;)

Sietse Touker
Commissioner of !IntervisiE & Communications

I am excited to be part of the effort to intensify the activities organized by OfCoUrsE!. I also hope to streamline our communication through our website and social media platforms.

Of CoUrsE! Crew

Bart van der Cammen

As an active member of of CoUrsE! I am excited to learn everything the association has to offer and help out with organizing all sorts of fun activities.

Janneke Bosma

So far, I really enjoy to be a member of Of CoUrsE!. Besides joining fun and interesting events I am also interested in learning how to organize these events as an association!

Jean van der Meer

As my first year in Eindhoven, I am really looking forward to helping the board and the crew with the association's activities. In particular, I will parttake in the team organized by Robin that will plan the next study trip.

Robin Pronk

Joining this study association allowed me to meet a great group of people. This year I will be putting some of my energy towards helping set up ofCoUrsE!'s 2022 studytrip.

Do you want to get involved with the board?

BIM CONNECTED

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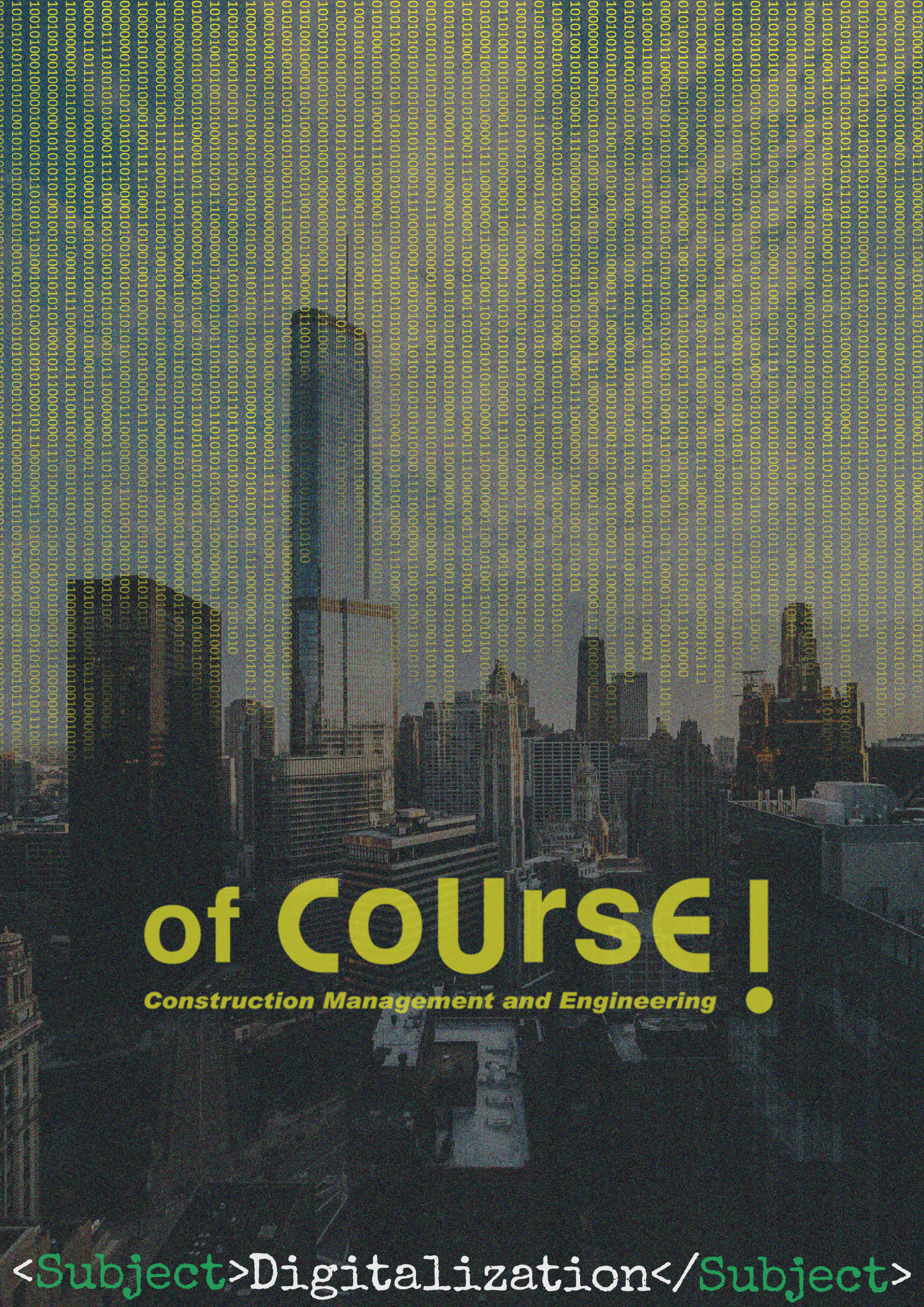
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<Subject>Digitalization</Subject>