

TOPOGRAPHY OPTIMIZATION

Collaboration between Twente Additive Manufacturing and Selkirk College



Site scan



Tim with column

It has only been a few months since Twente Additive Manufacturing showed up in their neighbourhood and they are fast becoming the talk of town amongst the tech community in the British Columbia Kootenays. Selkirk College researchers were invited by them to participate in a “world’s first” project so we were excited to jump at the idea.

*Bob Hall, Communications Coordinator & Community Liaison:
Selkirk College*

Selkirk College’s Digital Fabrication & Design Program is leading the charge in digital design post-secondary education. A program like this is not what one would expect in rural British Columbia, but the West Kootenay overflows with people doing the unexpected. For the last 150 years this region was known for resource extraction almost exclusively. Loggers and miners, that’s it. Tech jobs and tech training only happened for people willing to move to an urban center. Since 1966 however Selkirk College has been successfully flipping the paradigm on this outdated notion that rural communities are only good at creating blue collar workers.

Building on this philosophy, in September 2020, Selkirk College launched another ground-breaking initiative working

with their established leadership in technology advancement. They now offer a course with break-neck speed higher learning called the Digital Fabrication & Design Program. In just two-years they get students up to speed in all aspects of the computer aided manufacturing revolution that has been gradually redefining factories everywhere.

The initial cohort of 12 students is well into its mission of acquiring the education and skills needed to thrive in the world of design and manufacturing. In a field that combines the artistry of digital design with the skilled trades of making the physical form, learners in the program based out of Trail, BC arrived from a diverse array of backgrounds looking to build on skills for the future.

Partnerships are being sought with the companies developing and working in the field of 3D printing in the region. Selkirk College researchers from STAC (the Selkirk Technology Access Centre) visited the Twente Additive Manufacturing site in Procter over the summer to get a glimpse into what is possible. The excitement of the work collaboration opens doors of imagination to future student experience and a sector hungry for well-trained graduates.

“The cutting-edge technology of 3D printing with concrete at Twente Additive Manufacturing is so unique in this rural area and fits in so well to a region that has a long-standing history

of innovative and entrepreneurial minds,” says Shawn Curran, STAC Research Assistant. “The Selkirk Technology Access Centre combined with the new Digital Fabrication & Design Program will continue to support local industry and create innovation. The college is excited to prepare students with skills for the jobs of tomorrow, that are here today, in this amazing region and abroad.”

In the previous year, Twente Additive Manufacturing invented a new process to dramatically change how site preparation for home construction can be performed in environments where there is mountainous terrain or bedrock sticking out of the ground where the intend home will be built.

The concept at its most basic is this:

- **Step 1:** Scan the ground surface
- **Step 2:** Model the opposing element in CAD
- **Step 3:** Print the element upside down with concrete as a prefab element
- **Step 4:** Flip the print over and place on the ground surface to create a perfectly level foundation



Column placed – close

Column placed – distant



Column level check

PRODUCTION & APPLICATION

Twente is also working on a system to print directly onto scanned surfaces with their mobile printer but for now all their testing was based on the prefabricated and flipped concept.

Originally in 2019 Twente had scanned a large area using lidar and built a model for a luxury home that was going to be 3D printed to specifically nest into the pre-existing rock formations. The home was meant to be built starting in the summer of 2020.

Bob Hall had a brief conversation with **Jim Ziemplanski**, the site manager of Twente Additive Manufacturing's research and development lab in Canada.

Bob Hall: "Can you explain in a little bit better detail, what do you mean by Topography Optimization?"

Jim Ziemplanski: "Topography Optimization means that structural design takes into consideration the benefit of pre-existing building elements at a construction site and the architectural design utilizes these building blocks to dramatically lower the cost of the structure. By eliminating excavation activity, sites can be build-ready much sooner and at almost no cost compared to the expensive process of flattening a site that may have hundreds of tons of material that needs to be destroyed and displaced. This technique can also be used to recuperate elements of older foundations after a demolition and a new structure can be designed to utilize concrete structures at ground or below ground that still remain once the demolished 'soft' parts of the building have been removed.

Bob Hall: "This has nothing to do with Topology Optimization, correct?"

Jim Ziemplanski: "Correct, it is just a tongue-in-cheek name we made up to make whimsy of the amazing technology that is very trendy in 3D printing these days. Topology Optimization is 'growing' amazing parts that look almost organic and it is happening right across the engineering world through generative design. This has nothing to do with that, there are tonnes of papers on that out there, so we won't get into that now. It was our company president Ian Comishin who came up with the concept to 3D print concrete to rock scans, so he was the one who got to name it; he is always being a bit of a goof with things like this. Seriousness should be funny. The math that goes into Topology Optimization is incredible, we will get Selkirk out to learn about that process another day, I promise!

Bob Hall: "How come you didn't build the luxury house in 2020 like you had planned?"

Jim Ziemplanski: "We were all set to print a house designed to fit the scan area and initial drawings were getting hashed out when Covid hit. We decided it would be in bad taste to put all our efforts into something that was exotic and expensive, so we pivoted quickly to the affordable housing



Jim Ziemplanski

Geoslam scanner



crisis that virtually the whole planet is faced with. We conceived, designed and printed the Fibonacci house in just few weeks and have been using that as our first showcase home. This forced us to shelve the Topography Optimized house project for the time being.

Bob Hall: “You were already invited to present at Formnext in Frankfurt Germany on this subject though?”

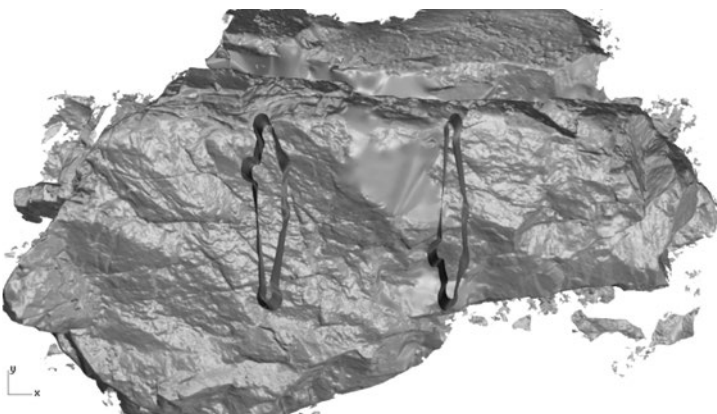
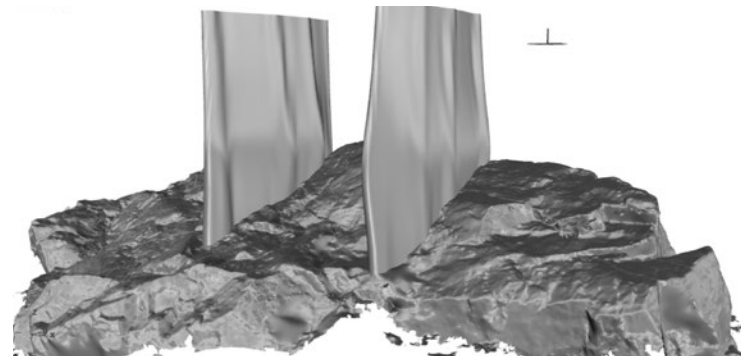
Jim Ziemiński: “Yes, to be honest it was a pretty crazy invitation. At Formnext there is an amazing symposium called “Be-Am”. Here we were being asked to publish an article alongside the European Space Agency, the Massachusetts Institute of Technology, ETH Zurich and several other giants in digital fabrication and education. We had to submit an article for this Be-Am publication which is a highly coveted review that I think was started by the research cluster of TU Darmstadt. It was an exciting yet scary invitation as it felt like we were getting called to the big leagues after only a couple months of training. The same week our deadline to submit came upon us, we were the head sponsor of TU Eindhoven’s Digital Concrete Conference in which we agreed to live printing everyday. We decided to throw the print of the Topography Optimized Column form into our live print sessions but of course we couldn’t tell any of the attendees what were printing because we wanted to be sure that Be-Am got the exclusivity of this publication. In BC we are nine

hours behind The Netherlands, so we were starting these live prints super early in the morning, or late at night... depending on how the staff chose to prepare for the day! We had a hydraulic hose that was not properly installed pop off and spray everywhere while we were live. Needless to say, Tim Brodessa, our project lead for the Topography Optimization research did not feel like talking to the camera with hydraulic oil all over his face. We were mad scrambling to give our spectators a real print experience.

Bob Hall: “There was a pretty big gap in time between when you submitted your paper and the symposium actually took place?”

Jim Ziemiński: “Yes, in fact we were on pins and needles for months after we submitted the article that no other 3D printing company would release any social media on the same subject. We wanted to be known as the inventors but also trying to be patient. We already started building a printer for one of our clients who specifically wants to create foundations using this technique as his main business model. We were surprised that a few weeks before the symposium that Be-Am offered us to put more content in their book. We of course had been focused on the Fibonacci house and they were super generous to include some details of that project even though it had nothing to do with the Topography paper. A few days before the symposium began, we decided

Rock scan



Rock scan overhead

Bar support printing





Bar support placement

to print some more Topography Optimized elements so that Tim could have more evidence of the technique working in his live presentation of the paper. We were in the middle of installing the world's first 3D printed playground for the City of Nelson and we had the Youtuber Jarrett Gross visiting at the same time, so we were scrambled again to say the least. This is when you [Selkirk College] came out and scanned a rock surface for us. We decided to print an outdoor bar on

the edge of a cliff that would use the natural rock as a base, 3D printed concrete supports, and sustainable harvested Douglas-fir from our local sawmill for the bar surface. Shawn came out with the Geoslam scanner and also with photogrammetry scanning which is used to develop a surface rather than using lidar. It is really incredible, basically thousands of photos are taken then the software uses pixel pattern recognition to take all these 2D data sets and overlap them



Bar level check



Permanent installation



Cliffside bar

until a 3D surface is created. It is quite insane how much data this technique uses yet how accurate the results were. Unfortunately, after we received the surface from Selkirk, we had lost the rock's position relative to gravity in the cad model so Ian and I had to head back to the rock with a level and a good old fashioned measuring tape to get the rock placed back into its real-world configuration. Ian and I argued over getting 2 points of reference or 3, and this would come back to haunt us at installation. Never trust a human to make a computer's decision."

Bob Hall: "If Twente invented this technique, did you get it patented?"

Jim Ziemplanski: "No, every single person employed in the 3D printing world has a career built on an open-source mindset. Twente will of course patent things that are specific to technology advancements that it has developed, but an idea such as this could have been imagined by anyone so it should be there for everyone to benefit from. We want to see 3D printing lower the cost of construction around the whole world, we will make our profits when we earn them, not by cornering everyone to have to deal with us through legal threats."

Bob Hall: "Are there any other applications that this technique can be used for other than building houses?"

Jim Ziemplanski: "Absolutely. We are working on a machine to print retaining walls next to train tracks, to create underground infrastructure such as storm water management and to shore up tunnels and excavation pits for the mining industry. There is really no limit to how much influence Topography Optimization is going to have on the construction industry."



Jim and Ian

Bob Hall: "So, what then is the future of Topography Optimization to the construction industry in your opinion?"

Jim Ziemplanski: "We foresee that there will be concrete 3D printers everywhere. They will be as ubiquitous as seeing excavators and dump-trucks on build sites. This is going to be the single biggest change in the construction industry of the decade. Anything that lowers the cost and improves quality of a build must be adopted by all the construction companies or they will get lost in the past." www.twente-am.com



Selkirk College is a community college in British Columbia, Canada. Founded in 1966, it was the first regional community college in British Columbia. www.selkirk.ca