
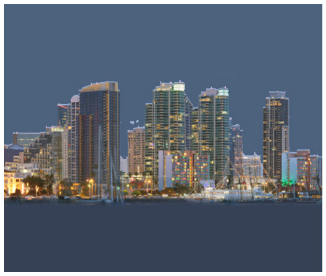

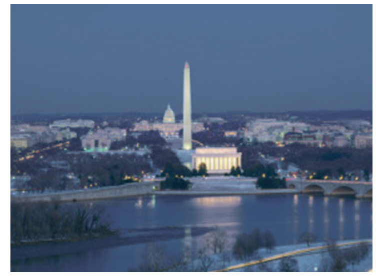

THE BROAD DIMENSION

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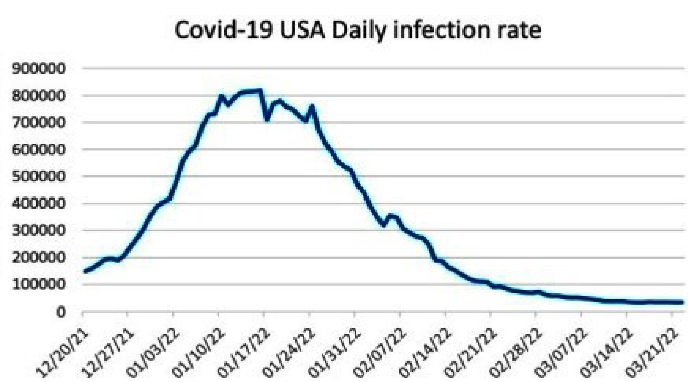
In this Edition:

What's Next?

As Covid numbers turned down, it seemed as if we were getting back to something resembling normal. Then Russia invaded Ukraine and we were almost back to the 1960s with people concerned about nuclear war. The situation in Ukraine is tragic, and the mounting sanctions are having a serious effect on the Russian economy, but that only appears to be hardening Putin's resolve. At least it looks as though China is resisting being brought in to prop up Russia and support their unwarranted aggression.



Of course, China is having its own problems, with widespread shutdowns as the Covid Omicron variant spreads across the country, giving its worst outbreak there in two years. Now we have Stealth Covid (Omicron BA.2) sweeping the world, and it can cause infection even if fully vaccinated, but in that situation the effects are normally mild and may not even be noticed.

With the interconnected world economy that we've grown used to since the end of the Cold War, people worldwide are starting to feel some of the pain as fuel and food supplies are curtailed leading to rising prices. Russia is a major supplier of oil and gas, especially to Europe, and Ukraine has been described as the breadbasket of Europe. Oil prices surged, then dropped back a bit due to talk of increased production by other OPEC members and the China slowdown reducing consumption. All of that is putting additional pressure on inflation and making the Federal Reserve's job of managing the economy even harder. In hindsight, they probably should have started raising interest rates in 2021, but they don't have a crystal ball and their decisions seemed logical at the time.

All of these issues are meaning that businesses are left with questions about the way the economy is headed. Those questions are making planning new projects a risky business, so many of those plans are likely to be put on the back burner until at least it seems as if we can tell what the future holds. Nobody likes using the word "stagflation" where inflation is high while growth is static or receding, but it is looking increasingly possible.

Construction work had been picking up as the pandemic showed good signs of fading into the background for real this time. The ABI had been showing growth for the 12 months through the start of this year, but the growth had been slowing as the labor and material challenges facing the construction industry continued to push up prices. The latest construction confidence index (CONFINDEX) was continuing to look positive, but that was immediately before the invasion of Ukraine. Material prices, supply chain delays, and skilled labor shortages showed up as the main problem areas. Contractors had a decent level of work backlog and continuing demand, which was leading to a decrease in competition while bidding. Now the Ukraine situation is causing even more disruption to the supply chain and, with the Fed expected to be pushing interest rates up on a regular basis to fight inflation, the availability and cost of financing will be adversely affected.

On the positive side, the US has the biggest economy in the world and a large portion of its gross domestic product comes from internal consumption, so we are likely to feel less effect than many other regions around the world. The infrastructure bill should also keep the workload up for many, even if it exacerbates the labor shortage. We will still see growth in facilities to support the aging boomer generation and apartments to accommodate the millennial and Generation Z, along with warehouses to facilitate the growth in online shopping.

Geoff Canham, Editor, TBD San Francisco

Robots in Construction

Staff shortages have been an issue affecting contractors for a long time, and robotics has been seen as a possible solution. Robots would have a number of advantages over human workers. For instance, being computer-controlled they can directly read from the BIM model, they can be very precise in their work, and they can work almost continuously, with downtime only required when maintenance is needed or when they have to move to another location.

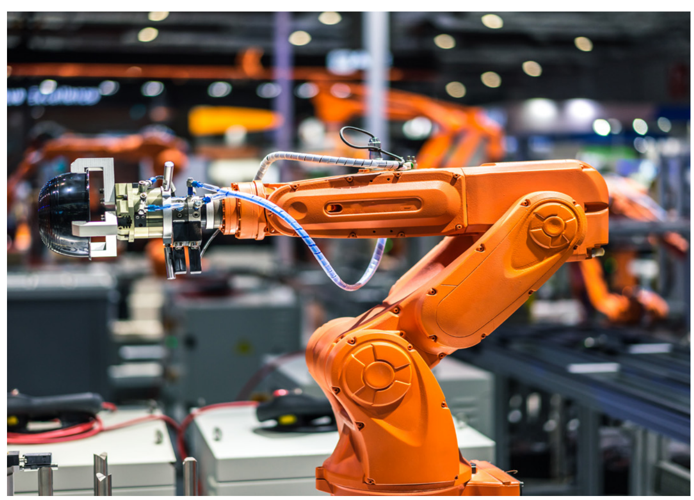
Robots have been used in industry to assemble automobiles and a multitude of products, but construction has a lot of other problems, such as constantly changing conditions, people and equipment moving around the site all the time, changing weather conditions, and jobs that are often non-repetitive. However, these are all issues that are being worked on and solutions are being found and improved on.

Automated excavators and delivery vehicles are already in use but, as with self-driving cars, we know the technology is not perfect yet. A self-driving taxi got confused by road cones and stopped in the middle of the road, blocking traffic, but there's always teething problems. Drivers have been known to get confused too, and as chaotic as a construction site can be, it probably doesn't get as bad as some road conditions. Negotiating a construction site isn't just moving around at ground level but can also involve the robot needing to be able to locate and use construction elevators. Connecting to elevator controls via Wi-Fi is already being used. Ladders would be a more serious problem, but someone is almost certainly working on that. There are already robots that can handle stairs, but working in construction regularly requires adaptability, and humans are still better at that than most robots are.

We now have robots that can handle welding, concrete laying, and brick laying, but many of these are really only at the prototype stage and not ready for general use yet. There are questions about their adaptability for unusual and special conditions, such as with brick laying robots where cables have to be embedded in the wall. Those robots are ideal for building simple and repetitive walls, although there are now brick laying robots that can produce intricate designs in the brickwork as well. Robots have also been used for demolition work, enabling workers to avoid some of the more dangerous situations.

Other specialist robots are also being developed, but the "specialist" nature of them makes them less economical, since a contractor would need to purchase and maintain a range of different robots for various tasks.

With the increased use of modular buildings, where major portions of the building are fabricated in factory conditions, robots can really come into their own. Even when the units being produced are not identical, the robotic fabrication process can be programmed to handle the differences and turn out consistent quality units in a production-line fashion. A measure of intelligence might even be built into the modular units to enable them to carry out at least some level of self-assembly.



The use of 3-D printing to produce structures is also now practical, and the technique has been used for such things as emergency shelters. As the technology is developed, no doubt it will become useful for more sophisticated structures. 3-D printing technologies and prefabrication results in less waste and better utilization of resources which improves the sustainability rating of a building.

The robots do not necessarily need to work autonomously. Remotely piloted drones and vehicles have been used for exterior painting and to place materials and equipment in places that could be awkward for workers to access, and are being used for carrying out inspections, especially in cramped or dangerous locations. Drones are also being used to provide site monitoring and to identify potential safety issues and safeguard workers' health.

We might even have human-robot hybrids. Exoskeletons worn by workers can increase a person's abilities and be used for situations where great strength and careful placing of heavy equipment is needed. Robots can also assist the manual workforce. For instance, cargo robots can be used to assist tradespeople by accompanying them while transporting needed materials and equipment.

Although it may not be considered strictly robotic, much of the administrative work involved with design and construction is being automated, as is some actual design work such as structural analysis and design, with the computer taking on the repetitive tasks.

As the robotic technologies develop, and people experiment with their uses, we will be seeing much more automation of construction related work. Yes, this will reduce staff, but they are already hard to come by, and we are seeing that people are less willing to engage in many such manual jobs. The use of robots will also create jobs that might appeal more to the upcoming generations because robots will need control engineers, maintenance and repair technicians, and computer programmers. The use of robots should lead to more productivity, as we have seen in industry, and that should result in an increased standard of living for all of us. Unless artificial intelligence gets too smart, and they begin questioning why they are working their little gears off for us.

The Greening of Concrete

Some form of concrete has been used as a construction material for about 8,000 years, and it has enjoyed that longevity because it is strong (in compression anyway), adaptable to multiple situations and designs, and it's quite easy to work with. The problem that we now need to address is that concrete is responsible for somewhere between 6% and 10% (5% - 7% for the cement content alone) of the world's annual emissions of carbon dioxide (CO_2), so there is a need to find ways to improve concrete's effects on the climate. It is estimated that producing one ton of Portland cement adds one ton of CO_2 to the environment. A large part of the impact of cement comes from the fact that it goes through a process requiring high temperatures. The other ingredients of concrete, namely aggregate and water, can usually be sourced locally and so require minimal transportation, and they do not need much in the way of processing and therefore contribute little to the carbon impact.

Probably the most interesting way to make concrete green is the use of carbon cured concrete. Concrete has to be kept moist to enable it to cure and reach its design strength and, in the traditional curing process, the CO_2 comes from the air. Such weathering carbonation is slow, taking days and can continue for months or years.

However, there are other ways of adding carbon to the concrete. Aramco and the Korea Advanced Institute of Science and Technology achieves 20% CO_2 uptake in the concrete by combining it with steam used to keep the setting concrete moist. CO_2 can also be infused under controlled pressure and temperature. Another method injects recycled liquid CO_2 into the wet mix stage of the process. Some methods of introducing the captured CO_2 might be more appropriate for the controlled environment involved when precasting, rather than for insitu concrete. The main chemical reactions from directly introducing CO_2 to the mix occur in the first few minutes of hydration, and design strength is achieved in about 3 days as opposed to something like 28 days with traditional methods.

Such carbon cured concrete helps the environment by utilizing post-industrial CO_2 captured from industrial and manufacturing processes and embedding it securely. It can also reduce the cement content by around 3% and still achieve an equivalent strength, although local building codes may dictate cement content. These methods do affect the design strengths, but they are largely equivalent and often improve the strength in comparison with traditional methods. Carbonation curing is said to protect better against freeze-thaw damage because the carbonation process leads to a denser product.

There are other ways to improve the carbon footprint of concrete as well. The use of certain admixtures to the concrete can absorb additional CO_2 during the curing process and also reduce water usage. The face of exposed concrete panels, etc., can incorporate embedded dye-sensitized solar cells, which have an efficiency around 10%, and be a green energy source. And of course, we can recycle old concrete for use as aggregate in new concrete or as gravel for the sub-base of paving etc. When using recycled concrete or other construction waste as aggregate, special care has to be taken in assessing its quality, especially for structural uses.

Since the vast bulk of the carbon impact of concrete comes from the production of cement, the obvious way to improve its impact is to reduce the amount of cement used in the

concrete, and happily there have been ways of doing that for quite a long time.

One method that has been known since the 1930s is the use of fly ash or other supplementary cementitious materials such as blast-furnace slag. Slag cement is often mentioned with regard to the greening of concrete, but there it is often not in relation to the environment but in connection with the blue-green color that the concrete can develop for a while. Fly ash has little, if any, cementitious properties in itself but it can develop them in reactions with calcium hydroxide. As such, it can be used to replace some of the cement (maybe 20% and up to 80% although somewhere in the middle of that range might be a good target). It has little effect on the strength of the concrete, although it can prolong setting times in cold conditions.

Fly ash can make pumping easier and make the cured concrete less permeable to water, etc., and less susceptible to shrinking and cracking. It is those cracks that allow moisture and pollutants in and leads to deterioration of the reinforcing steel, so fly ash helps make concrete construction more durable. The use of fly ash will also normally reduce the volume of water needed for concrete production, and water is a resource that needs conserving. Another use for fly ash is as a lightweight aggregate, and it has the advantage that it is a byproduct of other activities, so it produces no CO_2 in and of itself. Of course, the primary source of fly ash is from coal-burning power stations, which have their own serious drawbacks in relation to the carbon cycle.

Probably the best way to reduce concrete's impact is to use a sustainable substitute material, such as timber. But, while major advances in timber construction have occurred in recent years, it still doesn't meet all needs. Consequently, we have to examine all the options for making concrete itself more "green" and, along with that, make sure that local construction codes safely permit the adoption of advances in concrete construction.