welding 101

By Adam Pletsch

Museum pieces

Structural steel presented challenges to contractors at ROM

Asked if he's ever been on a similar project, John Martin says, "There is nothing similar to this." And it would seem he is right. The steel-and-glass dominated crystalline structure designed to house exhibits at Toronto's Royal Ontario Museum (ROM) is probably unique.

Martin is project director with Markham, Ont.-based Vanbots Construction Corp., the winning bidders on the project. Vanbots was actually selected before the architect was. The firm responded to a tender call, followed by a proposal call-back in the fall of 2001. It was officially selected in December of 2001 and in fact helped the ROM decide among the three architectural finalists. This decision was made in about February, 2002, and Vanbots then helped select the exhibit designer in April. Martin came on board in July, 2002 and will be involved until work is complete sometime around summer, 2007.

Complex structural steel was fit precisely according to a computer model.

PHOTO: ADAM PLETSCH.

The structural steel and many other elements of the design have made the project an unusual one. The six-crystal design challenged the welders since, especially in one particularly hot spot, the steel all comes together in a maze of connections. "They have 10, 12 pieces coming together and all the forces from all these crystals are coming down into one area. It's lovely welding work," says Martin.

Seven 600-V. welding machines are used on-site. The shielded-metal arc welding process is used with 7018 stick electrodes. All welds conform to CSA W59-03.

Much of the structural steel used was fabricated in Hamilton, Ont. by Walters Inc., with some welding done on-site. Workers just tend to bolt parts together on-site because it's more controlled and controllable.

Variability of design is the key to – and menace of – the job. The structural steel is set at an array of angles: 45 deg., 60 deg., 82 deg., "anything you can dream of," says Martin.

And while the structure will be stable when complete, it needs quite a bit of support during construction. The building of the six crystals required concrete floors to be poured first, since this holds the steel together.

This is in stark contrast to many construction jobs. "We have to put up all the structural steel. Then we have to hold it in place and pour all the concrete floors. When we take all the shoring out, then we can get on with the work. The whole sequence of the structural steel is really the complicated part," according to Martin.

This tends to slow down the workflow. For example, all the cladding (the watertight aluminum "skin" of the building) is made exactly to a 3-D model. Each piece has an assigned place, says Martin. "It's not made to fit what's there; it's made to fit where the computer says it should be."

As one might expect, not every architectural idea of the trend-setting design could be accommodated. Vanbots has a budget and a schedule, and some things just wouldn't work – either because they would have taken too long or been too expensive. However, the architect, Daniel Liebeskind, has been "quite receptive," when changes have been required, Martin says.

As an example, Liebeskind didn't want to use columns in the structure of the crystals (the upper floors). A compromise was reached, and there are now a total of five columns. "They're not straight, of course," laughs Martin, but the parties were able to come to an agreement. The cost of not having those five columns would have been immense. "So there's give and take, and there's been a good relationship," he says.

Another thing that complicates welding on the job is the fact that none of the connections are the same as the others. Liebeskind's steel sections and all his pieces are unique in shape, size and angle.

"Here there hasn't been one [piece] that's not different, but there also has been on-site, on-time delivery," explains Joel Parke, vice-president, client services for Vanbots.

"Therefore, everything that was put together had to be planned and organized so that it arrived in the morning on the flatbed and was hoisted and put into place at that time… There was very minimal on-site cutting and welding because of the quality and because of the difficulty of it. It isn't simply a situation where you can butt two pieces together. It's very precise," he says.

Shop drawings were not on paper; they were done using 3-D modeling. As a result, Walters' foreman carried a laptop, not drawings, around the site. The laptop was used to review proposed lift techniques of the members. Normally, a piece of steel would be picked up landed vertically. In this case, because workers are trying to land it at 60 deg., they have to know where the pickup points are to hold the steel at 60 deg. as they lower it onto the base plate – which still has vertical bolts. All the centre of gravity calculations are worked out in the computer, Martin explains.

Visitors to the site might also notice some strange orange bolts. The bolts match key bolts in the computer model. A totalstation is set up to locate the bolts in the field and the steel is moved so that the actual position in the field and the position in the computer model are identical. "They put the chains on it, and pull it and tug in, then hold it in place, working off the computer model. There are no grid lines, no 1, 2, 3, 4, a, b, c. This is just a massive set of 3-D coordinates," says Martin.

All cladding frames (the steel frames for the windows and cladding systems) are welded. The subcontractor is Joseph Gartner USA, part of a German company called Permasteelisa Group. There are currently 45 men on-site, working in two shifts on all the exterior envelopes, including the glass, the cladding and the aluminum extrusions.

The cladding is made in Germany. Frames come over in 40-ft. containers and are bolted together and lifted into place. They take up a huge part of the outside surface of the ROM's crystals. In fact, only 15 per cent of the building is glass; the rest is solid.

Perhaps one of the most surprising details of the construction is the fact that many sections of the museum have stayed in operation during the entire process. "John [Martin]'s not only dealing with 100-plus construction workers daily, he's also dealing with several hundred schoolchildren visitors daily," according to Parke. ◆

Adam Pletsch is a Toronto-based freelance writer with a special interest in welding.