An innovative technology

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Concrete domes are becoming the storage structure of choice as many companies search for a competitive and efficient approach to store bulk materials. Using the same technology of the inflated air form in the dome building process, the research and development team at Dome Technology of Idaho Falls, Idaho, USA have developed a way to build a tunnel faster and more efficiently than conventional tunnels, This article will focus on the advantages of this new 'inflated', concrete, arch tunnel and the technology used to develop it.

Some of the first domes that were built over 20 years ago, were used as potato storage. Most of these potato storage buildings have a long plenum in them to supply humid, temperature-controlled air to ventilation pipes that go under the potato pile while in storage. These plenums actually become tunnels under the potato pile using shotcrete technology. They were built by spraying shotcrete onto a wood, metal, or fabric form.

The first tunnel that was built under a dome was in Festus, Missouri, for River Cement. It was built in the conventional method using lots of wood forming material and prefabrication rebar. It turned out well but we could not help but think of the shotcrete tunnels we built under potato piles. We waited for the right opportunity to try to sell an air-inflated, fabric-formed tunnel under a dome. The opportunity came in the form of two engineers shopping for good value as they planned for a flyash storage. Gary Beckcom and Bob Lister of Monex invited Linden Fielding and Barry South of Dome Technology to San Antonio to discuss their project. Duke Power Co. operates a coal-fixed electrical power generator at Belew Creek, North Carolina, and Monex has the contract to remove and market the flyash from the plant. Since there is an excess of ash in the winter and a shortage in the summer it was decided to put in a large storage system. The system included:

·A dome 165ft (50m) in diameter by 82.5ft (25m) high that will hold 39,000 tons of flyash.
·An air slide floor system that moves the ash to a center discharge and into a pressure vessel in a bunker below floor level.
·A fabric-formed, air-inflated shotcrete tunnel that runs from the below grade bunker under the dome center, and on a incline up to the surface outside the dome.
·Piping for moving the fly ash from the pressure vessel through the tunnel and pneumatically conveyed 2,300 feet (700m) to a steel silo in the load-out terminal.
·A hydraulic bulkhead door (also designed by Dome Technology) to keep the flyash inside the dome and provide an emergency opening.

ARCH TUNNEL PROCESS
The tunnel is formed by attaching a single sheet of fabric to each side of a concrete slab that becomes the tunnel floor. The fabric is then inflated to form a flat-bottomed round tube 10ft (3m) wide an 8ft(2.4m)high.

After inflation, reinforcing steel was placed around the tunnel on the outside of the air form and then the shotcrete was applied from the outside. Spraying the shotcrete from the outside is opposite from spraying concrete on a dome which is done from the inside. Construction of the tunnel is simple and fast. Advantages over the conventional method are:
·Less material because of less surface area and the inherent strength of an arch
·Very little forming material
·Most rebar is supplied in stock cuts rather than being prefabricated

The construction process is constantly being refined as better methods are researched.

Arch tunnels that are scheduled to be constructed in the near future will have some changes that will make construction even faster and better. A major component of building an air form structure are air inflators that are versatile and reliable. The amount of air pressure used is determined by the amount of upward lift needed and the strength of the air form that is used. Too much pressure can lift a concrete foundation or 'pop' the air form. An average size dome that we build will be inflated with two inches of water column pressure. When compared to atmosphere pressure, which is 14.7 pounds per square inch (psi) , it is very low. Atmospheric pressure will lift a column of mercury about 30 inches at sea level or a column of water about 33 feet. Two inches of water column pressure equals about .07 psi. When a person walks into a dome while it is inflated at .07 psi the pressure change that you experience is about the same as you feel when you descend about 160ft in elevation. Some of our crew worked several months last year in Hawaii at 14,000 ft elevation. The pressure change in the two hour ride from sea level to the top of Mona Kea was about half of the atmospheric pressure or about 7.35 psi, which is about 100 times the pressure in a dome. Even though the .07 psi in a dome is a slight pressure it still requires a great deal of weight to hold the air form down. A 200ft diameter dome will lift about 80 yards of concrete.

Another innovation that is a result of working with the engineers at Monex, which in now a part of Boral Industries, is a single sloped floor. The sloped floor with an air slide will eliminate the need for a tunnel altogether. A new design for a bulkhead door that will be opened only occasionally will further reduce the cost.

The construction supervisors at Dome Technology, Barry and Randy South, each have over 20 years of experience in building monolithic domes and the company has quality assurance programs that address building procedures. There are parts of the construction process that need very close attention to avoid problems. Some of these include:

·Application of urethane foam. Both Randy and Barry have been spraying foam for at least 25 years and know the temperature and humidity conditions that affect urethane. In addition to field training of foam application, periodic formal seminars are held and the technicians are instructed on the proper procedures for applying polyurethane foam.

When a mistake is made in the foaming process it can mean a blister, which leads to a void. Off-ratio foam can lead to dimensionally non-stable foam which will show up later from the outside as a pucker in the dome surface. There are numerous ways to spray foam that will lead to delamination between layers or from the airform. The delaminations turn into blisters that show up on the outside of the dome.

·It is important to know how to place rebar so that there is concrete coverage between the foam and structural rebar.
·Certain standards need to be met for proper embedment of rebar with shotcrete. Dome Technology has implemented placement and inspection procedures to insure proper rebar embedment.
·It is very easy for a shotcrete nozzleman to spray a little bit too much concrete on an airform and sag the airform. Again we cover this part of dome building very thoroughly in our seminars.

RECENT PROJECTS
Dome Technology is currently involved in some great dome projects. Four storage domes and four domes for schools are currently being finished. A fertilizer storage project involving several domes in Argentina was recently started.

Several domes storage projects began in November 1997 in Washington, California and Arizona. A dome measuring 286ft (100m) will soon also be started.

The excitement that we anticipated a few years ago has turned to reality - and we are still excited. Domes are exciting and practical buildings.

BIOGRAPHY
Barry South is the President of Dome Technology, Inc. He was born and raised in Idaho, USA. His early years included working at the family logging and sawmill operation at Island Park, Idaho. After attending high school in Idaho Falls, Idaho he spent two years in Texas, USA as a Mormon missionary. He graduated from Brigham Young University with a degree in Business Management. Prior to dome construction, Barry worked with his brothers David and Randy in the business of spraying polyurethane foam. He has been building domes for over 20 years.