STOCKPILE ENCLOSURES

Rudi Pieterse

INTRODUCTION

Few people will ever be able to change life as we know it, but inventors can invariably be found amongst the Chosen. The love of mankind and a concern for the future of the planet, together with an engineering ability, is the mark of a great soul. Richard Buckminster Fuller, inventor, engineer, architect, mathematician, designer, poet, and philosopher was a truly great soul and visionary, who believed technology could save the world from itself, providing that it was properly used.

He believed that one man can make a difference and dedicated his life to making that difference. It was, of all things, the geodesic dome that dominated Buckminster Fuller's life and career. Cost-effective, lightweight and easy to assemble, geodesic domes enclose more space without intrusive supporting columns than any other structure. They also efficiently distribute stress, and can withstand harsh conditions. These structures are based on his "synergetic geometry," his lifelong exploration of nature's principles of design. The geodesic dome was the result of his revolutionary discoveries about balancing compression and tension forces in building, which he patented in 1954.

Richard Buckminster Fuller's principles of synergetics proved space was tetrahedral and his designs were based on a geometry that used triangles, circles and tetrahedrons, rather than the traditional planes and rectangles.

STOCKPILES

Stockpile management is an important part of the materials handling process from mine to customer. Virtually all producers and consumers make use of stockpiles at their facilities, either to serve as a buffer between material delivery and processing, acting as a strategic stock against supply interruptions, or to enable material blending to meet quality requirements. With mounting pressure to minimise the capital tied up in stockpiles, there is a global need to optimise inventories.

Stockyard operators are under constant social and political pressures to improve the environmental acceptability of their operations. Thus control, prevention and monitoring of fugitive dust emissions, and the composition, collection and treatment of stockpile runoff are addressed. Experience has shown that with good stockpile design and management, most materials can be safely stored in an environmentally acceptable way.

Stockpile enclosures are not new to the South African industry. Conventional clear span buildings have been used to cover material for decades. These took advantage of the benefits of keeping the material dry and to prevent it from being blown away. Material from woodchips to limestone has been covered. However, these have been for relatively small stockyard capacities.

In this paper, we will consider unconventional methods of stockpile enclosures, focussing on traditional high capacity stockyards, be they circular or longitudinal, as they appear to be the most common in the South African industry.

Environmental concerns have made it more critical to prevent material contamination: the first recent project was Skorpion Zinc (Anglo Base Metals) in Namibia. The EIA required the containment of the product to prevent pollution to the sensitive desert environment. The solution was a fabricated dome structure clad with galvanized sheeting.

The cement industry is concerned with the production benefits gained by keeping the material dry. Internationally, these limestone stockpiles are almost always enclosed. The increase in kiln operating costs due to the wet material is sufficient to justify the millions of Rands spent on covering stockpiles. An added benefit to the enclosure is the better flow of material through the system, due to fewer blockages and less maintenance requirements.

SHAPES

The shapes of the enclosures are largely dependent on the stockpile layout. This in turn, is determined by the stacking and reclaiming system. Smaller capacity operations may have a conveyor with a tripper suspended from the roof, stacking the material in a longitudinal stockpile while being reclaimed with front-end loaders into hoppers. The normal clear span type galvanized sheeted roofs usually enclose these rectangular shaped stockpiles.

Circular stockyards are common in the coal and cement industry. These have a circular stacker reclaimer, hence the need for dome type enclosures. These could be either a fabricated dome structure or the modular geodesic dome, clad with galvanized sheeting. Developments in vinyl and inflatable structures are also an option, albeit with some durability concerns.

The conveyor arrangement in greenfield applications may utilise the structure to support the feed conveyor to the centre of a circular stockpile. Longitudinal stockpiles may use the enclosure structure to support a traveling tripper, leaving unencumbered access to earthmoving equipment for reclamation of the material.

Access is also required to the enclosed area, be it by loading-vehicles or small trucks. This is necessary for the maintenance of the stockpile equipment.

The civil support for these structures is limited to a foundation and a low wall on which the structure is anchored.

Figure 1: Lichtenburg Lafarge Domes

CASE STUDIES

CLINKER STOCKPILES, LAFARGE LICHTENBURG, SOUTH AFRICA

Diameter: 113 m

Type: Modular Geodesic Dome

Erection of the dome starts with typical civil construction, which includes the necessary bulk earthworks and the digging of a basic trench for the foundations. This is done without interrupting the normal operation of the site. The civil design for the domes in Lichtenburg was done in South Africa, but conformed to the manufacturer's guidelines.

Once the trench has been prepared, both the trench and the surrounding earth is compacted in preparation of the insertion of the reinforcing cage. This cage is assembled on site, before being positioned and aligned inside the trench.

With the necessary shuttering in place at the lower level, the first pour of concrete takes place, after which the shuttering is stripped down again. A second pour of cement follows, now at a much higher level. Once this has been done, the bars are bent and laced, and the anchoring pipes for the dome itself are cemented onto the top of the civil construction. With the foundations complete, construction of the dome itself begins.

Once the amount of available space for each dome has been determined, and the designs for the structure approved, the components for the dome are manufactured. Manufacturing takes approximately two months, after which all the components are shipped to the site within four to six weeks.

Shipping takes place in purpose-built containers, each with a unique number and barcode, which is not only crucial for identification on the construction site, but also facilitates multiple shipments of components. This means that construction can potentially start on the site once the first containers arrive, with further shipments arriving as manufacturing at the source continues.

Each of the dome's components has a specific location in the construction, and as such, are carefully matched using barcodes and detailed information. Each sub-structure is assembled on ground-level at the building site, before being positioned and secured in place by hand.

With the structure complete, another pouring of concrete takes place over the reinforcing bars at its base, as well as the anchoring rods for the dome itself. The next step is to cover the entire structure with conventional, galvanised IBR sheeting, though clients have the option of specifying translucent sections as well as chromadeck finish if required.

The sheets are pre-creased on the ground, before being hoisted into place and secured using posidrive screws. The creasing is done in order to compensate for the curvature of the structure, and again no special tools are required. The amount of off-cuts is minimal, and most of these cut-sheets are re-used during the final construction phase.

A high emphasis is placed on safety throughout the construction, and workers are pre-selected based on their ability to deal with the considerable heights involved in the building process. Safety procedures were drafted and implemented, with regular safety drills. The result was no time-loss injuries during the Lichtenburg/Lafarge construction, bearing testimony to the high safety standards achieved.

The dry product enters the dome via a conveyor, which feeds the stacker. One of the major advantages of the dome enclosure is that it significantly limits the amount of dust generated by normal stacker operation. This is due to the fact that there is limited air movement within the dome, causing the dust to settle much faster than on uncovered material stockpiles.

Dust control is only a by-product of the dome as its primary function is to keep the dry material free of moisture, which can impact on the operation of material handling systems and may also cause disruption of the kiln operation. Since the dome removes both these scenarios from the manufacturing process, it contributes to the smoother operation of the plant, and also brings manufacturing costs down significantly - especially in areas where high precipitation or wind are factors.

Vehicle access around the stockpile is retained, facilitating easy access for maintenance.

These geodesic structures can be built over an existing stockpile, without interrupting the stacker operation during construction. No large cranes are required on the construction site, and no large laydown area is required.

Each dome covers the original stockpile. 15,000 m^2 of sheeting is used per dome, to cover and area of 10,000 m^2 - including the material stockpile, circular stacker-reclaimer and wide access-way for maintenance.

Four doors are included in each dome's design in order to facilitate easy access. Each opening consists of an electrical roller-shutter door, with a smaller door built-in for pedestrian access.

Both perimeter and area lighting are included, and is in accordance with industry standards. Power points are also provided at each door for welding and general applications.

UPS power is supplied for emergency lighting, and each dome is earthed and designed to withstand severe weather conditions including lightening strikes.

Figure 2 and 3: Clinker Stockpiles, Lafarge Lichtenburg, South Africa

ZINC STOCKPILES, SKORPION ZINC ROSH PINAH, NAMIBIA

Diameter: 93 m

Height: 30 m

Type: Homogenous self-supporting shell dome

In 2003, the design of the massive dome structure enclosing the circular stockpile won the 'Best Entry' award in the industrial projects category of the SAISC (Southern African Institute of Steel Construction) Steel Awards, as well as recognition in the engineering machine category. The following year, it won the top 2004 global award at MINExpo in Las Vegas, USA.

The 50 000 t ROM stockpile is equipped with a circular-stacker-bridge reclaimer. Designed to blend the ROM, it stacks at a rate of 460 t/h and reclaims at 380 t/h. The 85 m-diameter stockpile is contained within a 93 m diameter dome for environmental protection, making this the first such installation in southern Africa .The self-supported, shell-designed dome would almost cover a rugby field. It is constructed from 9 800 m² of 0,6 mm Chromadek sheeting. Maintenance access is provided via four 5 m x 4,5 m roller-shutter doors. The dome becomes a homogenous self-supporting shell, which relies upon membrane action for its overall stability. Special consideration was given to the method of erection in order to maintain stability at each stage prior to the onset of the membrane action.

The circular stacker/reclaimer is totally enclosed, which prevents stockpile dust from contaminating the surrounding area and windblown dust from contaminating the stockpile.

The design, which was largely influenced by the sensitivity of the surrounding ecology, is the first of its kind in southern Africa. The South African engineered, detailed, fabricated and erected structure was cost-effective and makes use of local material's availability.

The remoteness of the site, the logistics of assembling on site and the programme restraints called for large elements of the stacker/reclaimer to be pre-fabricated.

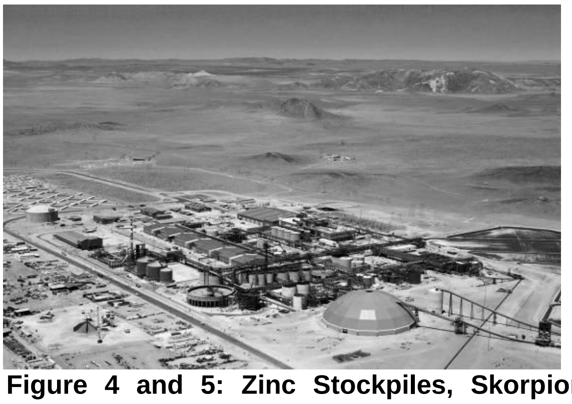

Figure 4 and 5: Zinc Stockpiles, Skorpion Zinc Rosh Pinah, Namibia

COPPER ORE STOCKPILE ENCLOSURE, ESCONDIDA, CHILE

Span: 60 m,

Rise: 30 m

The crown of this structure supports the conveyor gantry over the stockpile. The static and dynamic forces are transmitted to the foundations via 14 lateral steel arch trusses spaced 12 m apart. It was designed to carry the load even if one of the trusses becomes ineffective, should some failure occur.

Triodetic framing between the trusses is designed as a series of curved single layer shells (toroids) spanning 60 m x 15 m and rising to 30 m at the roof apex. Stand-off brackets to accept linear horizontal purlins, curved decking and translucent panels were positioned with the frame sections during all pre-assembly at ground level and then sequentially positioned.

For the end wall, a vertical twin layer space frame was designed and installed. These walls are self supported and require no foundations. This allows for the expansion of the stockpile length, with only the relocation of the end walls.

One of the major advantages includes reduced foundation loads when compared to the conventional A-frame structure.

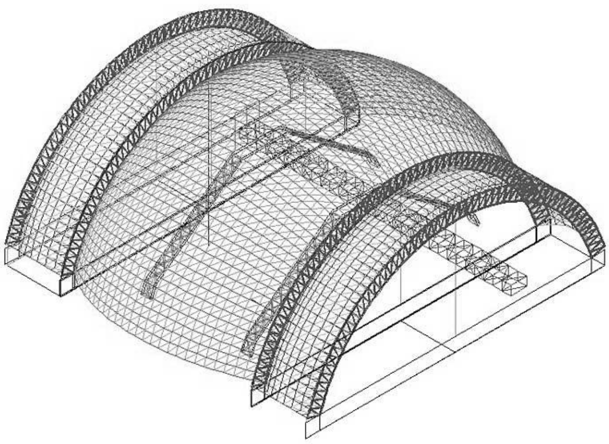

Figure 6, 7 and 8: Copper Ore Stockpiles Enclosure, Escondida, Chile

ELK RUN COAL COMPANY/ MASSEY ENERGY- BULK STORAGE

Size: 82 m (w) x 149 m (l)

Height: 34 m

Type: Translucent Acrylic Air Supported Structures

This application has a very interesting history. The Elk Run Coal Company is situated close to town. The environmental impact of the airborne dust infuriated the community leading it to take the coal company to task. After an extended battle, the community won and the coal company undertook to tackle the problem.

Their options were limited, covering an operational stockpile and doing it quickly. The Elk Run Dust Containment Dome is a first-of-its-kind. It comprises an air supported vinyl coated polyester building to cover coal stockpiles, preventing coal dust from reaching nearby communities. The building is supported only by air pressure supplied by an electric blower, which also provides fresh air while equipment is operating inside the facility. The continued operation is backed-up by two additional back-up blowers and a generator to ensure that no mechanical failure or power outage will cause the dome to deflate.

Access is provided by openings that allow track and earthmoving machines to enter the structure. The coal enters the dome from conveyors and is then distributed to stockpiles inside of the structure, while the constant flow of air keeps the interior free of condensation and moisture. The structure's coated fabric also provides protection from ultraviolet radiation. The interior space is completely clear span; there are no columns or interior posts.

For ease of installation the structure was made in sections and mechanically sealed with aluminium non-rusting clamps. The structural support comes from a bias cable net system that meets structural code requirements for 295 km/h winds.

The structure comes with a ten year guarantee. In 2007, a dozer ventured too close to the side and ruptured the membrane. This caused the complete structure to collapse, rendering the stockpile inoperable. However, after a repair to the ruptured membrane, the stockpile returned to full functionality.

Figure 9: Elk Run Coal Company/Massey Energy - Bulk Storage

CONCLUSION

The mining industry will become more conscientious of their impact on the environment and the environmental agencies will remind them, if they forget. In the end, economic benefits will just make it easier for the mines to do the right thing.

After a family tragedy, Buckminster Fuller entered two years of seclusion to begin, in his own words: "...the search for the principles governing the universe and help advance the evolution of humanity in accordance with them... Finding ways of doing more with less to the end that all people everywhere can have more and more..."

The geodesic design that emanated from this affords us not only the opportunity to enclose stockpiles to protect the future for our children, but also to increase the efficiency of our plants.

This surely must make Buckminster Fuller proud that with his invention, we are of doing more with less to the end that all people everywhere can have more and more.

AUTHOR'S CV

Rudi Pieterse received a National Higher Diploma in Mechanical Engineering from the Vaal Triangle Technicon and followed this with a Master in Business Administration from the University of Potchefstroom. He has more than 15 years experience in application engineering of slurry pumping, crushing, screening and materials handling systems.