Thermal mass – specifically in the form of rock stores - is the "quiet achiever" of the green building world. When used in the right conditions it can save considerably on energy, and provide hidden benefits such as water savings and attractive design.

WORDS MICHELLE LUDWIG

A SOLID ARGUMENT

Using building materials with mass as a thermal comfort strategy is not a new idea – think of the coolness of a large cathedral or the warmth of a sun-warmed stone floor. However, this strategy employed in the form of rock stores is being successfully implemented in a growing number of local projects to provide comfort and save energy on air-conditioning.

When it comes to managing air temperature, thermal mass can be described as the "quiet achiever" of the building world. "When correctly sized and utilised in appropriate climatic conditions, rock stores can offer substantial energy savings," says Francois Joubert of Greenbuild Consultants, who has designed and modelled performance of rock stores for a number of projects. "The design solution is extremely robust and reliable, and requires almost no maintenance. Unlike most mechanical systems, rock stores have a life expectancy similar to that of the building."

Rock store systems typically consist of fans drawing outside fresh air through a bed of stones, which have been either chilled or warmed depending on the climate and seasonal need. This pre-heats or pre-cools the air before it enters a space. During periods when the tempered air is not sufficient for comfort levels, it can be directed to a conventional air-conditioning system, which brings the air to optimal delivery temperature. In this approach, the heating or cooling load is reduced, requiring less energy from HVAC equipment.

In summer the rocks are "recharged" for the next day by drawing cool night air through and purging the built up heat. If used for winter heating, they can be warmed by the sun's radiation or other heat sources.

WHERE IT WORKS

Rock stores are not suitable for all projects in all locations. One important prerequisite is climates that have a large diurnal temperature swing, which is the difference between day and night temperatures. Such conditions are experienced in many climatic regions of the country for large parts of the year, says Joubert. "The limited supply and high cost of electricity, labour-intensive economy, and locally available materials favour the use of rock stores in the African context," he adds.

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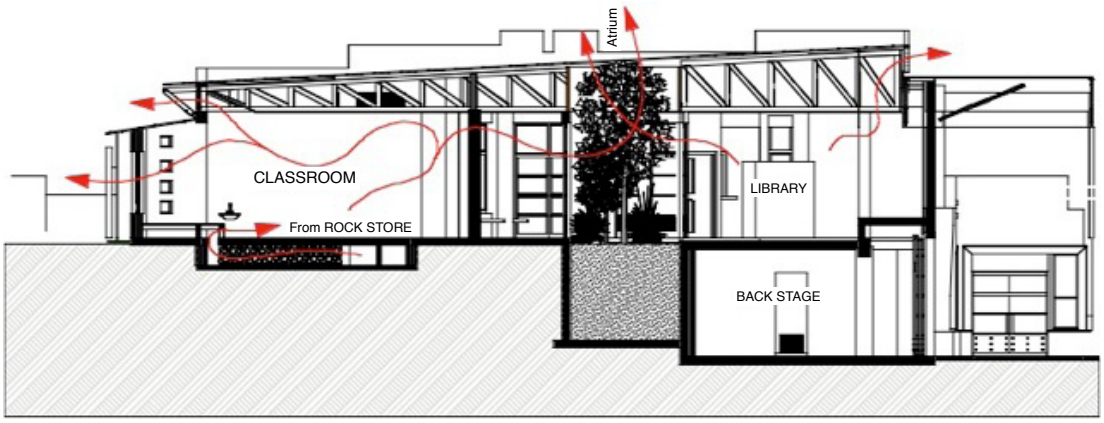

The diurnal temperature swing in Stellenbosch lends itself to using rock stores in Lynedoch's Community and Education Centre.

LYNEDOCH COMMUNITY AND EDUCATIONAL CENTRE

Constructed in 2002, part of the Lynedoch Community and Educational Centre encompasses primary school classrooms. Located in Stellenbosch, which has a suitable diurnal temperature swing, the project employs an underfloor slab rock store built with local river boulders and precast concrete planks. Using only low-power fans to circulate air, the system helps mitigate the temperature in the classrooms year-round without the need for conventional air-conditioning. The mechanical consulting engineer on this project was Mike Rainbow.

In winter, warm air generated in the roof cavity during the day is pumped through the rock store and into the classrooms. While warming the classrooms by approximately 10°C, this also warms the rocks, which then release their heat at night. The rock store is located below some classrooms, which has the added benefit of reradiating its warmth through the floor slab. The next morning, when outside temperatures are cold, the classrooms are still warm.

"When some of the students are coming to school without shoes, a few degrees warmer to start the day becomes important," says project architect Alastair Rendall of ARG Design. In summer, cool night air is used to flush out the heat build-up from the classrooms as well as re-cool the rock store. During the day, the warm outside fresh air is then pumped through the cooled rock store into the classrooms, lowering the temperature by approximately 5°C.

CTI CAMPUS RANDBURG

In 2008, the electricity shortage caused difficulties for new development proposals to be allocated power supply from municipal councils. Developer and quantity surveyor Basil Walker of Walker Maré requested 330kV for his Randburg office building project but ultimately only received permission for half as much. His only option was to design a building that required significantly less electricity and as a result multiple energy-efficient interventions were employed. One of these interventions was a three-storey rock store situated at the end of the building, which created a dramatic design feature.

Making use of the Highveld climate's cool night air, the rocks are cooled overnight by an extractor fan. During the day, pulling the fresh air intake across the rocks reduces the incoming temperature by approximately 7°C. The air is chilled to required needs by an ice storage air-conditioning strategy.

The cumulative effect of these energy-efficiency interventions means the building's monthly electricity costs are 57% less than those of a similar nearby building. The maximum demand has been approximately 110kV, one-third of the project's initial request.

The vertical arrangement of the rock store was primarily a result of the advanced stage of the design and spatial limitations at the time. The building, now the home of CTI Education Group's Randburg campus, will be renovated and expanded in the near

The three storey rock store is cooled overnight by an extractor fan. During the day, pulling the fresh air across the rocks reduces the temperature by about 7˚C. Initially used in an office building in Randburg, the rock store will be dismantled, relocated and reconstructed at CTI Education Group's Randburg campus.

future. The rock store will be dismantled, relocated and reconstructed. Having learned from the first attempt, Walker says in its next incarnation a few design changes – such as a vertical rock flow orientation, the ability to wet the rocks at night and placing it underground - will further improve its efficiency and reduce the construction cost.

The mechanical consulting engineer on this project was Anton Frylinck.

VODAFONE SITE SOLUTION INNOVATION CENTRE

This widely lauded, 6-Star Green Star SA project in Midrand incorporates two rock stores for separate functions. Cool air from the first rock store improves the efficiency of a dry cooler, which is an air-based heat rejection approach in lieu of more typical water-dependent evaporative cooling, says Alison Groves of WSP Green by Design. This approach also helps reduce overall water consumption, which was one of the project's goals.

The second rock store is used conventionally to pre-cool outside air before it is supplied to the building as fresh air supply. If the incoming temperature is desirable, it does not require additional tempering, otherwise it is further cooled to the right temperature by the air handling units' chilled water-cooling coil.

The rock stores are created from gabion baskets filled with recycled rock from the excavation of a nearby building site. Woven mesh gabions are a newer method of creating rock stores, with advantages such as inherent strength, durability, ease of construction, modularity and cost effectiveness. "A rock store was always part of the project goal," says Groves, "but concerns about locating it externally, such as wet and mould, provided a natural progression to put it under the building and then using the gabions as foundations as well. The added ecological benefit was a 43% reduction in the foundation, reducing the use of cement content in the overall structure."

The rock stores form part of multiple energy-efficient interventions that, together with renewable energy, help the building achieve its net-zero energy goal.

The building was designed by GLH Architects, with the rock stores and HVAC system engineered by Steven Barrett, former WSP mechanical engineer, now with Graeme Page Consulting Engineers.

HILLSIDE CLINIC

This single-storey rural clinic in Beaufort West, currently under construction, is a pilot project for the Western Cape government and the Department of Transportation and Public Works. While aiming for carbon-neutrality, the design goals were to create a robust, low-maintenance building with high reliability, explains architect John Wilson-Harris of Gabriel Fagan Architects.

Beyond the good sense basics of orientation, solar control, insulation and high-thermal mass walls, multiple smaller rock stores are incorporated

The two rock stores at the Vodafone Site Solution Innovation Centre are created from gabion baskets filled with recycled rock. Using woven mesh gabions improves strength and durability while making construction easier, more modular and cost effective.

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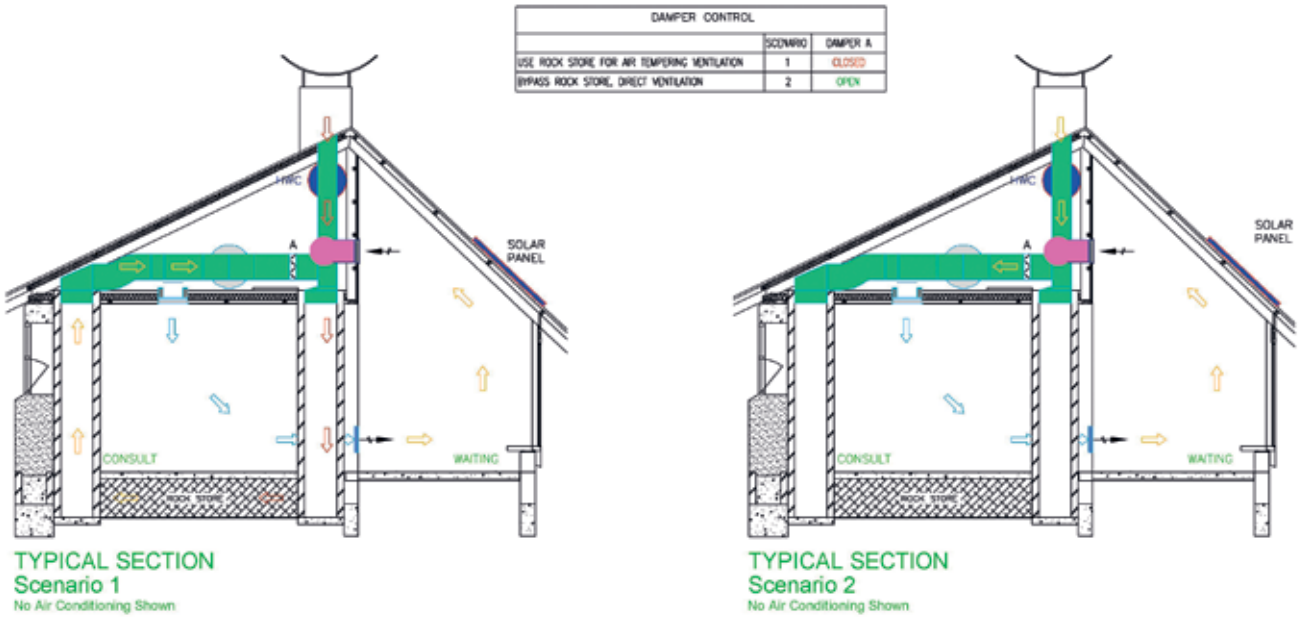

At the Hillside Clinic in Beaufort West, Western Cape, rock stores will contribute to the goal of a carbon-neutral building.

throughout. Due to an open layout and varying conditioning requirements, Joubert says the stores are decentralised and are located closer to where they are needed.

"This has several advantages, like less ductwork, being able to fit it in under available floor space right where you need cooling, and elegantly tying in with the distributed A/C units," he says.

BARRIERS TO IMPLEMENTATION

"Where rock stores are used to augment naturally ventilated buildings, ideal conditions should not be expected at all times," says Joubert. "However, the number of occupied hours during which acceptable thermal comfort conditions exist will be significantly increased."

Incorporating a rock store could have significant capital costs related to the availability of appropriate rock material and the space required for the rock store. The construction cost of the rock store and requisite ducting could also have a slightly higher initial cost compared to mechanical solutions such as A/C split units. However, in Rendall's experience, the cumulative operational cost savings over time, as well as reduced maintenance, make rock stores a good choice for daytime occupied spaces.

Technical understanding, such as appropriate sizing and arrangement for a rock store design that will meet a project's requirements, is important. Mechanical engineer Patrick Costello of Spoormaker and Partners says the surface area at the entry and depth of the rock store will influence how much air you can pull through and for how long you will have cooling. Joubert has also determined how the shape and packing density of the rocks influence both pressure drop and heat transfer capability.

While the strategy is simple in concept, traditional mechanical engineers may be hesitant to evaluate and embrace this alternative approach. In typical commercial projects, there is less motivation to explore and implement less expensive systems when the engineers' professional fees are determined by the final cost of the mechanical solution installed. Sustainable architect Eric Noir suggests that projects should figure the engineering fees for what would be a typical commercial system as this could provide more incentive to explore alternatives.

Noir, who has explored rock stores for multiple projects, also recommends that architects and engineers sit down together and physically draw the design arrangement to scale, including its spatial and equipment requirements in lieu of just diagram symbols. "Once you see 'how much' and 'where it goes', the strategy becomes more palpable and easier to wrap one's head around," he says.

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