In many areas of southern Africa, flat, featureless terrain makes the location of road construction materials difficult. Thick covers of sand add complications in the arid and semi-arid areas of the west and in the coastal plains of the east.

As part of a larger study, various methods were investigated to locate road construction materials. These included traditional techniques with maps, aerial photographs, and satellite images, as well as some innovative techniques, such as looking for geobotanical indicators.

Problem
Traditional methods of material location entail a desktop study of the road alignment on geological and topographical maps, plus aerial photographs and even satellite images, to identify potential sources. A field survey follows.

In many developing countries, aerial photographs and satellite images are not available. Moreover, geological and topographical maps are of little use in flat, featureless terrain with a deep sand cover.

Sparse population and the lack of infrastructure imply few records of gravel sources. Many contractors therefore resort to field studies, which can consume months of often-fruitless investigation, leaving scars on previously unspoiled landscapes.

Solution
The presence of many plant species and even the nature of their growth often depend on the mineralogical and physical properties of the soil. In the past, plant indicators have been used to locate various minerals and metal ores; however, data and documentation on the use of these indicators to locate construction materials are minimal.

Many road builders of the preceding generation placed great importance on interpreting the natural vegetation when pegging alignments and locating materials. Much of this knowledge, however, has been lost as these field-trained staff have retired.

Literature Study
The literature on the topic is limited to locating calcareous materials such as limestone and caliche in Africa by identifying plant species with a high tolerance for calcium, like *Catophractes* and *Grewia*. However, an investigation of the vegetation around a variety of known material sources in various geological regions revealed that the presence of certain species was restricted to the immediate area of the source and not beyond; for example, *Stoebe* species was found near laterite.

Location of similar growth patterns elsewhere in the landscape sometimes indicated similar materials. The study also revealed that morphological differences in certain species—such as stunted growth in *Acacia* species and *Colophospermum* species—often indicated changes in material or in other relevant factors, such as perched water tables, impeded drainage, or areas with high clay content.

*Catophractes alexandri* or trumpet thorn can indicate caliche deposits.
Application

Economic developments in southern Africa and plans for growth dictated the need for a corridor linking the port of Maputo in Mozambique on the east coast of Africa with Walvis Bay, a port on the west coast of Namibia. The 2750-kilometer-long corridor would cross four countries.

Most of the western sections of the road traversed sparsely populated, arid areas with only a basic infrastructure of vehicle tracks. The area is flat, featureless, and covered with thick layers of mostly wind-blown sand. The vegetation is predominantly scrub savannah, and the only road construction materials are the sand and isolated deposits of caliche and arkose.

Without suitable aerial photographs, the contractor for one of the Botswana sections of the road resorted to a ground study. The lack of roads in the area and the presence of thick scrub savannah vegetation hampered the investigation, and an alternative was sought to prevent further costly delays.

A repeat ground study to locate potential botanical indicators was considered inappropriate because of the nature of the terrain and the lack of infrastructure. The alternative of acquiring aerial photographs also was rejected because of the costs and the time requirements.

An aerial survey to search for botanical indicators therefore was proposed. An ultralight aircraft (see photo, this page) was selected because the plane is slow, highly maneuverable, and inexpensive to operate in comparison with a helicopter; a fixed-wing aircraft generally is too fast for this kind of visual survey.

The following procedure was used:

♦ The aircraft was flown approximately 200 m above the ground along the proposed alignment.
♦ The area to the left and right of the route alignment would be searched for any abnormalities in (a) the microtopography, such as pan rims; (b) the vegetation, such as a distinct change of species, a dense thicket of one or two species, or a change in plant morphology; or (c) the soil color. The key plants

North Dakota Vegetation Yields Clues to Construction Materials

In the United States, although particular plant species have been associated with the presence of certain materials, the information seldom is used to locate aggregate sources. An exception is North Dakota, which lacks surface and near-surface rock exposures—the state department of transportation (DOT) relies on vegetation indicators to locate aggregate for road construction.

North Dakota DOT employees look for plants such as big sand grass, pigeon grass, and crested wheatgrass to locate gravel pits. According to DOT observations, woody shrubs, such as buck brush and sage, do not thrive well in gravelly areas, and at midsummer the well-drained areas typically burn or thin out—another indicator. Because North Dakota is an agricultural state, crops also have provided clues to subsurface conditions.

In southwestern Oregon, unique vegetation is associated with ultramafic and serpentine rocks in the Klamath Mountains. The Oregon white oak is known to indicate well-draining material such as sand and gravel in the Puget Lowlands of Washington State. The pink prairie cone flower grows near limestone in southeast Kansas. These associations, however, have not been used to locate potential materials for road construction.

The technique developed by South Africa and Botswana, described by David Jones in the accompanying Research Pays Off article, offers a successful model for reconnaissance work to develop new sources of road construction materials, applicable in the United States and other countries.
proved to be *Catophractes alexandri* or trumpet thorn, *Grewia flava* or brandybush, and *Pecheuelloeschea leubnitziae*.

- When a plant site was observed, the pilot flew the aircraft to the area for a closer inspection from the air. If any of the indicator plants were noted, the Geographic Positioning System coordinates were recorded and a subjective rating was given to facilitate and prioritize later site visits.

- After inspection, the ultralight aircraft was flown back to the route along the alignment until a new potential site was discerned.

With this procedure, a 60-kilometer section of the route was traversed in approximately 3 hours. A total of 14 potential sources of material were identified in the area already surveyed unsuccessfully in the earlier ground study.

Five of the sites, selected at appropriate points along the route to minimize haul distances, were visited in the following two days with a backhoe loader. All of the sites contained caliche of varying quality and quantity, 1.0 to 2.0 m below the surface, which is common in the terrain, and is included in contract pricing practice. Tests on samples removed during this expedition showed that sufficient material could be excavated to meet the required standards for the various layers and the surface treatment.

**Benefit**

A 3-hour ultralight aircraft flight using botanical indicators to identify potential sources of materials, followed by a 2-day site inspection, located sufficient material to build a 60-kilometer section of road. A 2-month field survey in the same area using traditional techniques had failed to locate the sources.

The costs for the pilot, the materials specialist, the aircraft, and the field allowances amounted to approximately $2,000. In comparison, the costs for a geologist, an assistant, and vehicle and field allowances for the traditional survey totaled more than $8,000. The time and cost savings with the ultralight aircraft survey are evident.

Although finding suitable road construction materials is never a guarantee in any survey, the prescribed technique enhanced the ability of the prospector to find suitable material or to know beyond reasonable doubt that suitable materials were not present. The technique has been used successfully to locate materials—or to confirm that none were available—in several projects for which traditional methods were unsuccessful or inconclusive.

South Africa and Botswana have developed guideline documentation on the use of botanical indicators in material location. Although these studies were undertaken in southern Africa, the procedure is applicable to any area with similar conditions—such as the southwestern United States, the Australian interior, or the Middle East.

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