Technical Case Study:

Neoloy® Tough Cell Stabilized Feeder Roads, UN, South Sudan

Table 1. Case Study: Project Snapshot (source: PRS Geo-Technologies)

Description:	**Creation of basic road infrastructure to provide security, aid and opportunity in remote regions of South Sudan characterized by poor site conditions, undeveloped markets, and political and food insecurity.**
Subgrade Soil:	Sand, loam and clay soils, 7% CBR, isolated marshland
Client:	UNOPS – United Nations Office of Project Services, South Sudan
Project Design:	WSP|Parsons Brinckerhoff, South Africa
Results:	• Helping people – sustainable access for food, aid, security and regional development • Permanent road achieved using local soil materials • 50% cost savings compared to conventional design • 35% faster installation– all-weather construction (and all-weather use) • Sustainable objectives achieved – environmental and social
Date:	Dec 2016 through Feb 2017
Keywords:	Gravel road, road design, Sudan, UNOPS

Fig. 1. Installation of Neoloy Tough Cell on Rural Feeder Road Project, UN

Fig. 2. Neoloy Tough Cell Reinforced Rural Feeder Road, UN

1.1 Introduction

One of the least developed countries in the world, the new country of South Sudan faces enormous challenges. Large parts of the country lack basic road infrastructure, which severely impacts all aspects of life: farming and economic opportunities are impeded, political-security situation becomes more perilous, and displaced people and ensuing food crisis is more acute.

A vital strategy to address the chronic food insecurity, improve livelihoods and stimulate rural development is to improve the rural road infrastructure and provide sustainable access to markets. It is also critical for essential aid to get to those in need.

The United Nations Office of Project Services (UNOPS) together with the South Sudan government and the European Union (EU) established the 'Feeder Road Construction Project.' The goal is to increase small farmer's food production and sustainable livelihoods with access to market; An unforeseen but increasingly urgent goal is to enable safe, reliable access into these regions by international aid organizations for aid to displaced populations in distress.

The Engineering firm of WSP|Parsons Brinckerhoff working as consultants for the United Nations Office of Project Services (UNOPS) arrived at an optimized pavement design for 225 km of roads that crossed four regions. Conditions included poor subgrade, high traffic loading, and a lack of quality aggregate, all in a very remote and underdeveloped region, subject to tribal conflict and food insecurity.

After extensive investigations and road design analysis, WSP proposed soil stabilization with Neoloy Tough Cells. *"Considerable distances between the project road and approved gravel borrow areas also contributed to the selection of this solution."* The subsequent UNOPS tender specifications for the type of geocells were based on the following design considerations:[1]

- Mechanistic design analysis
- Use of low-quality infill material
- Overall stiffness required for expected stresses and strains
- Limited allowable creep for pavement life cycle

[1] UNOPS, Invitation to Bid (ITB) for supply and delivery of geocells material delivered to Mombasa, Kenya and/or Kangi, Achol Pagong and Gok Machar in Greater Bahr el Ghazal Region, South Sudan. Section II: Schedule of Requirements. ITB Ref No: UNOP/SSOC/88050/ITB/GOODS/2016-001-Rebid (2016).

The UNOPS tender stated that:

> *"the application of (Neoloy or approved equivalent) geocells on this project is for a **permanent** solution, rather than a **temporary** solution, as is often the case with haul roads or access roads. This project specifically requires a long-term stabilization of the layer to withstand high traffic loads, which correspond to the upper allowable envelope for gravel roads. This is the reason for the specification for long term creep of the geocell material."*

UNOPS awarded the tender for the supply and delivery of ½ million sqm of Neoloy Tough Cells, which met or exceeded the UNOPS tender Minimum Technical Requirements for elastic stiffness, creep resistance and tensile strength.

1.2 Soil

The subgrade is generally characterized by sand, loam and clay with no rock outcrops. Black clayey loam and sedimentary material occupies the isolated marshlands. A significant part of the roads is in areas with poor subgrade material and/or poor drainage conditions, including marshlands. Average CBR of these soils is 7%. Seasonal rains cause flooding and makes large sections of road impassable due to poor design, construction and maintenance.

1.3 Conventional Solution

The road design includes a wearing course, a base (formation) layer and in-situ material roadbed (subgrade layer). WSP considered several types of conventional solutions. A conventional pavement design according to the South African Pavement Design Manual comprised the following:

- 200 mm gravel wearing course
- No subbase
- Local fill material (CBR >7%)

However, the conventional pavement design was not feasible due to the considerable distance between the borrow area for the gravel wearing course borrow area and the project road. This distance, coupled with large haulage fees, made this design option unfeasible.

1.4 Neoloy Tough Cell Design

In order to reduce the amount of gravel required for the wearing course, only two Tough Cell pavement design options were analyzed (see **Fig**. **9**). The Neoloy Tough Cells confine the in-situ material and improve compressive strength. The 330 mm small cell size and 120 mm height were chosen as the most effective configuration. The Neoloy Tough Cell design improved the subgrade elastic modulus between 1.5 and 5 times, while the subgrade elastic modulus was improved by a factor of at least two times.

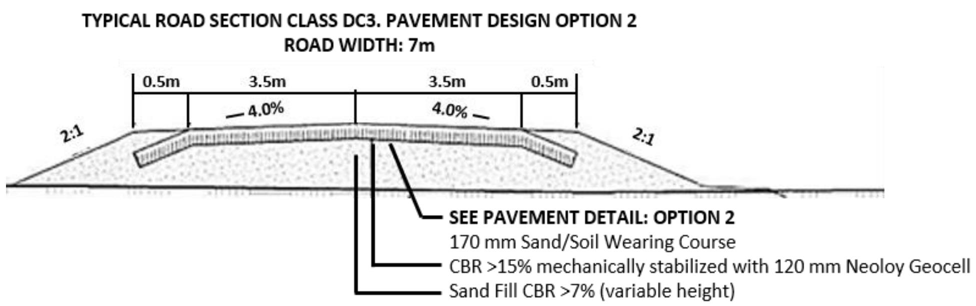

Fig. 3. Typical road section drawing with Neoloy Tough Cell base reinforcement (Source: WSP)

The Average Annual Daily Traffic (AADT) less than 300 therefore this road has been classified as a Low Volume Road (LVR) of design class DC4 with an intended level of service C. This road category provides for a DV4 design vehicle which is equivalent to a truck and semi-trailer. The design standards applied to this road are:

- Design speed: 50 km/h
- Road width: 7.0 m
- Minimum stopping site distance: 125 m
- Horizontal radius: 250 m
- Gradient: < 2%
- Super elevation: 4%
- Camber: 4%

The design and tender included a non-woven, needle-punched continuous-filament synthetic geotextile for separation, filtration, and drainage, and to reduce construction times over soft ground.

1.5 Installation

Over ½ million sqm of Neoloy Tough Cells were delivered in 16 weeks to Nairobi port, from which they were distributed overland to the UNOPS logistics centers and then to the local road sites. The project included knowledge management transfer, which included training local work crews in the use of Neoloy Tough Cells. The involvement of the local population was a key aspect of the project, as stakeholders in the construction and maintenance.

The Neoloy Tough Cells were incorporated in the wearing course of the 7.0m wide road with significant overfill. The road is basically constructed from sand, with the higher quality sandy-gravel infill limited to the wearing course. It should be noted that unforeseen delays were caused by the unstable security situation in the region.

Fig. 4. Installation and infill of Neoloy Tough Cell on rural feeder road project

Fig. 5. Finished feeder road

1.6 Results

The UNOPS, WPS, local government officials and the local contractors involved in the project expressed full satisfaction with the product, the installation and the stabilized road performance. The project was submitted by the UNOPS project management team to the annual UNOPS project of the year award. Additional tenders for Tough Cell soil stabilization were issued, for example in airfield pavement rehabilitation in South Sudan.

A key achievement of the project was a 50% cost savings compared to conventional design: due to the reduction in construction costs – reduced pavement thickness, less hauling (use of local sand, faster construction and reduced maintenance). This also helped achieve UNOPS sustainable objectives due to the road's durability, low environmental impact (using local materials) and employing the local populace in the road construction and maintenance. Installation time, costs and resources were also reduced by an estimated 35% due to reduced pavement thickness and in-situ placement.

Finally, this project literally stabilizes an unstable world and helps people and improves their lives. The roads are literally a live-saving artery in the short-term for the reliable delivery of food aid to get to those in need; and a key element enabling the development of a rural economy and opportunity for a better life in the long run.