Challenges in the Construction of Highways in the Brazilian Amazonia Environment:

Part I - Identification of Engineering Problems

Abstract

The construction of highways in the Brazilian Amazonia Region is always problematic, mainly because it involves environmental obstacles but also technical, economic, and natural challenges. The environmental issues concern the deforestation of the virgin forest and the resulting environmental impacts. The technical ones are related to the natural subgrade, formed by the geologically young alluvial soils that are plastic, being highly compressible and/or expansive, present in the vast Amazon Basin, whereas the economic issues refer to the final costs of inputs for the construction of the layers of the highway since granular soils and stony materials are located in limited areas that are distant from the work sites, given the geographic immensity of the Brazilian Amazonia.

There is also the cost of purging low-bearing capacity soil from the natural subgrade of the highway. Added to all this are the issues of nature, which involve high annual rainfall and the hydrological regime of river flooding and ebbing, which induce the saturation of the pavement layers and the loss of the global geotechnical stability of the compacted earth embankment, respectively.
This work points out the Engineering difficulties to be faced in road infrastructure works in the Brazilian Amazon.

Stabilization of Amazonian soils with chemical additives

Before, during, and after floods caused by river floods or intense rains, the quality of the road infrastructure is essential [63].
During these events, pavement layers consisting of nonconsolidated (flexible) materials are more susceptible to erosion, while consolidated (rigid) materials are prone to failure when the lower layers are subject to erosion.
Thus, evaluating pavements consisting of the in-situ transformation of natural subgrade in a rigid base layer with cement and specific additives may be an option for regions with a lack of stone materials and flood risk.
Some studies have shown the benefits, even in subgrades of low bearing capacity [64] of a reduction in the final thickness of the asphalt course.
The properties of cement-stabilized materials are strongly determined by the nature of the raw material used, which may be clay, silt, sand, or gravel.
The type of soil influences the choice of stabilizer and controls the structural properties of the stabilized product.
To a large extent, the variability of soil properties comes from the particle size distribution, arrangement of the particles, shape of the grains, and mineralogical composition [65].
Soil-cement structures are prone to hydraulic retraction, especially during the moisture loss caused by cement hydration or temperature changes.
The accumulation of cracks caused by shrinkage can accelerate the damage to the pavement, the erosion processes, and the reduction of the strength and durability of the base layer.
Conversely, the addition of synthetic zeolite additive, together with cement, for in situ soil transformation modifies the cement hydration process on a nanometric scale, improving the formation processes of the crystalline microstructure, exchange ionization, adsorption, and immobilization of potentially harmful compounds in soils that, in a traditional approach, would need

to be removed or discarded, at significant cost, making them relevant and suitable materials to be used in road construction [66] (Figure 13).

RoadCem additives can increase the strength and stiffness of the soil–cement composites and improve the overall performance of the stabilized layers of pavement [67–69].

In the State of Amazonas, laboratory tests performed in clayey soils have revealed a gain in simple compressive strength (SCS) tests when adding (RoadCem®) to its composition [70–72].

For field application, this additive is used at a low dosage (1.2–2.4 kg/m3) [73].

The dosage of the additive can be increased based on the local conditions, such as the soil characteristics, the time of the opening of traffic, and the climatic conditions present during construction.

Figure 14a shows scanning electron microscopy (SEM) images of soil stabilized with 8.2% cement, without additive, and with 0.174% additive (RoadCem®) (Figure 14b) for the submerged curing condition.

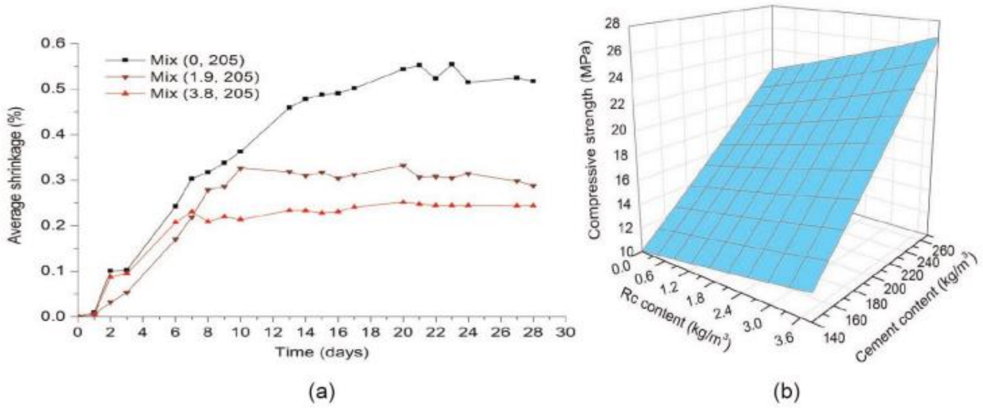

Figure 13.
(a) Effect of synthetic zeolite on shrinkage reduction and (b) on SCS gain as a function of dosage (adapted from [73]).

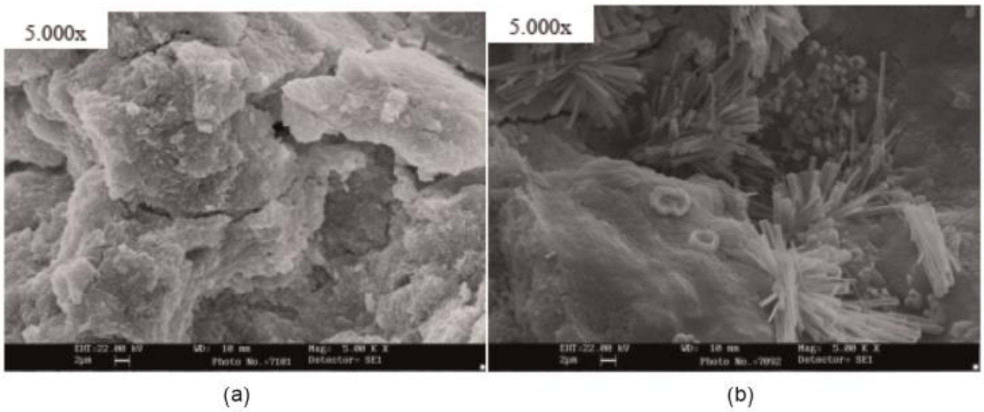

Figure 14.
Scanning electron microscopy (SEM) images of stabilized soil with 8.2% cement: (a) without; and (b) with RoadCem® additive, for submerged curing at 28 days [72].

The samples were cured for 28 days, and the products of cement hydration and pozzolanic reactions (cation exchange and flocculation) already took place, joining the flocculated clay particles. A denser and more complex structure was observed in the samples with RoadCem additives, indicating a greater amount of cement hydration products. Ettringite crystals (calcium sulfate and hydrated aluminate, with a size of 1 µm) were formed in needle shape in samples with the additive under both curing conditions.

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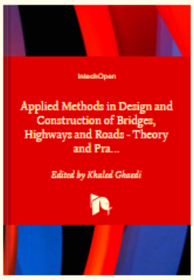

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