APPLICABILITY OF CALCIUM CARBIDE RESIDUE FOR SOIL STABILIZATION: A SYSTEMATIC REVIEW AND A META-ANALYSIS

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The use of Calcium Carbide Residue (CCR) which is a calcium-rich material as a soil stabilizer is often discussed as a solution to reduce negative environmental impacts and costs involved with soil stabilization with cement. By mixing an optimum CCR content with soil, a significant improvement can be achieved in soil properties. In terms of compaction properties, the addition of CCR decreases the maximum dry density (MDD) of soils while increasing the optimum moisture content (OMC). A significant increment of unconfined compressive strength (UCS) is observed with the increment of CCR dosage. However, the UCS of stabilized soils tends to decrease with further addition of CCR once the optimum CCR content is reached. In addition, the plasticity index (PI) of natural soils decreases with the addition of CCR and becomes constant after the optimum CCR content is reached. This particular research studies the applicability of CCR as a soil stabilizer with a comprehensive literature review and several statistical models and correlations were developed to be used in the pre-feasibility stage of applying CCR as a soil stabilizer. Prediction models were trained and validated by analyzing the data collected from similar studies using the statistical tools available in Excel and MATLAB software. This study describes a multivariate linear regression model and a multivariate polynomial regression model which can predict the MDD, and OMC of soils stabilized with CCR, respectively within a prediction accuracy of ±5% using the compaction properties of natural soil and CCR mix proportion. Also, an artificial neural network (ANN) model with a R^2 value of 0.99958 and an accuracy range of ±16% was developed to predict the UCS of CCR-stabilized soil after a curing period of 28 days. In addition to that, a gaussian process regression (GPR) model was introduced to predict the plasticity index (PI) of CCR stabilized soil with a R^2 value of 0.98 and a predictive accuracy of ±3%. This model can also be used to estimate the optimum CCR content.

Keywords: Artificial Neural Network; Calcium carbide residue; Regression analysis; Soil stabilization; Unconfined compression strength

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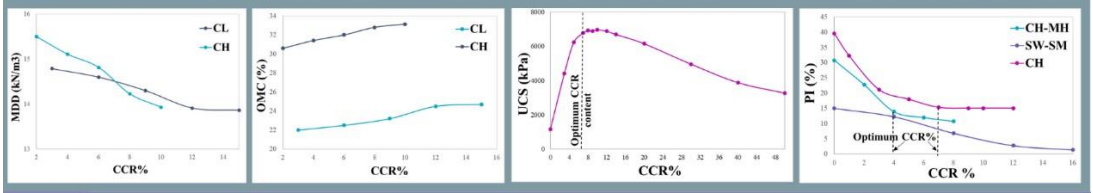
Systematic Review — **Observed improvements of the properties of soil with the addition of CCR**



CCR ↑ **MDD** ↓ **OMC** ↑ **UCS** ↑ up to optimum CCR% **PI** ↓ up to optimum CCR%

Meta Analysis — **Developed Models to predict the properties of CCR stabilized soils**

Dependent variable	Independent variables	Analysis technique	No. Of training data sets	R^2	Accuracy
MDD	MDD_{Soil}, CCR%	Linear regression	30	0.9027	± 5%
OMC	OMC_{Soil}, CCR%	Polynomial regression	30	0.9862	± 5%
UCS	UCS_{Soil}, CCR% Gs_{Soil}, Gs_{CCR}	Artificial neural network (ANN)	34	0.9996	± 16%
PI	PI_{Soil}, $Clay_{Soil}$ CCR%	Gaussian process regression (GPR)	25	0.98	± 3%

Regression Models

$$MDD_{(TS)} = 0.91545 MDD_{(Soil)} - 0.06829 CCR\% + 1.022403$$

$$OMC_{(TS)} = 46.13 - OMC_{(Soil)}\, CCR\% \left(0.036 - 0.0008\, OMC_{(Soil)} + \frac{4.95 - 0.25\, OMC_{(Soil)} + 0.003\, OMC^2_{(Soil)}}{CCR\%} - \frac{0.54}{OMC_{(Soil)}} \right)$$