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Research Paper

CBR PREDICTION MODEL WITH GIS APPLICATION TECHNIQUE

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The subgrade must be able to support loads transmitted from the pavement structure. This load bearing capacity is often affected by degree of compaction, moisture content, and soil type. A subgrade that can support a high amount of loading without excessive deformation is considered good. The overall strength and performance of a pavement is dependent not only upon its design but also on the load-bearing capacity of the subgrade soil. Thus, anything that can be done to increase the load-bearing capacity (or structural support) of the subgrade soil will most likely improve the pavement load-bearing capacity and thus, pavement strength and performance. In this research five different fine grained soils were collected from different zone of Al Basrah city (60 samples from Al-zubar to Al-faw). Preliminary laboratory tests, such as grain size distribution, LL, and Plastic Limit (PL) were conducted in accordance with AASHTO specification. A total of 60 soil samples were prepared for CBR testing for socked and unsoaked soils. Soaked and unsoaked CBR models were developed considering various independent variables: swell index, optimum moisture content, maximum dry density, PH value, SO_3% content and TSS% contents. The GIS tools are used in this research to manage the database and develop thematic maps for soil properties, liquid limit, plastic limit , CBR value, TTS content, maximum density and optimum water content.

Keywords: CBR, Subgrade soil, GIS, Soaked and unsoaked, Regression model

INTRODUCTION

recent in comparison to its own applications such as water resources, agriculture, geology, metrology, etc. As for as geotechnical engineering is concerned, inclusion of the spatial attributes of the data is itself a significant advance over common practice, where the spatial component of these data is often ignored through the averaging of multiple data values from different locations and application of a safety factor to account for variability among other factors. The soil as a

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whole is a complex material, it is always heterogeneous and non-isotropic, because of which profile of soil will be entirely different from place to place In order to decide the suitability of foundation for any structure, any location, and any loading, certain characteristics of soil (such as allowable bearing capacity) is to be estimated through performing subsoil investigations.

A Geographic Information System (GIS) in an interactive computer-based mapping tool that is able to store, display, and analyse spatial data (USGS Eastern Region PSC 4). It is very unique because it is able to integrate different information into one map. Another benefit of GIS is that it has a number of functions and tools that the viewer can use to interact with the data (Huntley, 2010).

The main objective of the present research was to develop regression-based models for estimating CBR value of fine grained subgrade soils for Al Basarah City considering different soil parameters were considered in the regression models:

- Swell index
- Optimum moisture content
- Maximum dry density
- pH value
- SO_3% content
- TSS%
- PI%

A commercial software (STATISTICA 5.4) was used to developed the models.

SOURCE OF DATA

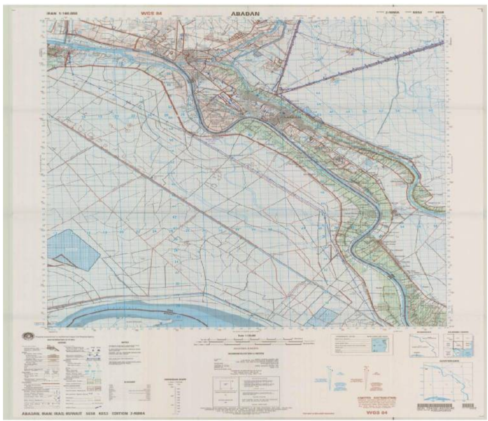
The data source is represented in two methods:

- The traditional data
- Remotely sensing data

The Traditional Data

Topographic map data scale of 1:100000 were used. Reports of previous studies about the study region were used as a part of available data, Figure 1.

Figure 1: Topographic Map of the Study Area, Scale (1/100000)



The Remotely Sensed Data

One of the main data sources used is Landsat7 ETM+, 3-visible bands with (14.25 m) resolution, acquired in March 2004; Table 1

Table 1: LANDSAT7 ETM+ Sensor Characteristics

Band No.	Spectral Range in Microns	Ground Resolution (m)
1 .	45 to .515	30
2.	525 to .605	30
3.	63 to .690	30
4.	75 to .90	30
5.	1.55 to 1.75	30
6.	10.40 to 12.5	60
7	2.09 to 2.35	30
Pan	0.52 to .90	15

Source: Al-Daghastani (2003)

refers to the LANDSAT7 ETM+Sensor Characteristics:

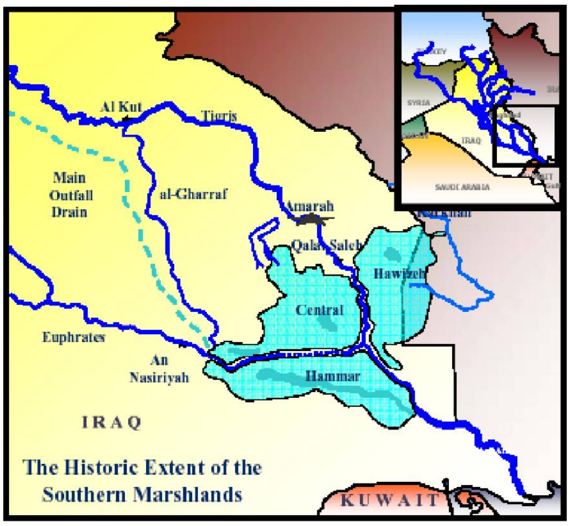
EXPERIMENTS WORK

Study Area Description

The Little Washita drainage basin in the southern part of the Great Plains in south of Iraq has been selected.

The study site covers an area of 610 km^2, and has a long term hydrologic monitoring facility. The climate of Little. Washita region is classified as moist and subhumid with an average annual rainfall of about 750 mm (Jackson and Schiebe,1993). During the experiment, land cover in the drainage basin was dominated by pasture and senesced or harvested winter wheat (Jackson and Schiebe,1991) . The forest cover within the basin was very sparse and constituted a small proportion of the basin. Figure 2 shows the location of the selected study area.

Figure 2: Location of Study Area



One of the main data sources used is Landsat7 ETM+, 3-visible bands with (14.25 m) resolution, acquired in March 2004; assigning study site in the selected satellite image since it must be characterized with the following:

The field work was based on the traditional methods and Remote Sensing data. Remote Sensing techniques were used to reduce the traditional field survey according to its facilities. Field observations were presented by acquiring (60) soil samples from different location of the study region by using Global Position System, GPS (Etrex) Appendix 1 describe the characteristics of this instrument.

Number of samples is specified depending on the primary survey for the study area that includes knowing the topography of the area, type of soil, and spectral response of Earth features that are represented in FCC image. The topographic map used was considered as a basic guide in the field work.

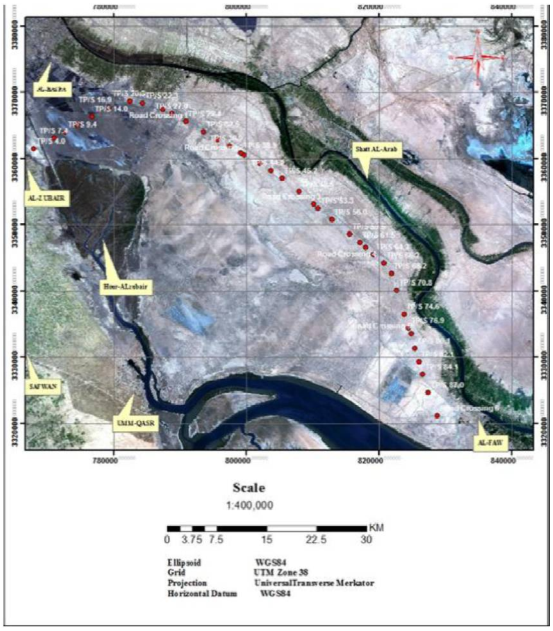
Applying GIS Techniques

Spatial Data and Attribute Data

The tests results collected from tests reports were linked to their geographic locations, through their easting and northing records, in ArcMap9.2 software to build a GIS database for the study region. Borehole locations were projected on the corrected image, and the format of the table of the geotechnical properties recorded in each borehole were converted to a suitable format (dbase IV) to construct the attribute table of the various points in the study area.

The format of each cell of information (fields) in the attribute table were set to its suitable form (string, integer, double, float etc.) in order that information can be used properly by the software. Figure 3 shows the distribution of

Figure 3: Location of the Study Area in Landsat7 ETM+



borehole locations in the study area. The boundaries of each of the five districts (Hays) in the study area are also shown in the figure. The boundaries of the study area and the hays were digitized from the digital map collected for the city with a scale of 1:100000 (Figure 1).

ArcMap9.3 was used to produce thematic maps of the study area concerning the distribution of various properties across the study area (Figure 4). The capabilities of GIS techniques were used to produce overlay maps between two or more properties to present the combined effect of those properties (Figures 4 to 6), while(Figure 7) is represent the Connect Attribute Data to Road Core borehole Exist in the study area by using ARCGIS9.2.

The first thing needed is the suitable satellite image for the purpose of the study , that have high resolution to determine the location of samples. Also have the ability to enable us for estimate the required acceptable data in the image format those needed by the correlated

Figure 4: Data Base of the Borehole Shape File by Using ARCGIS9.2

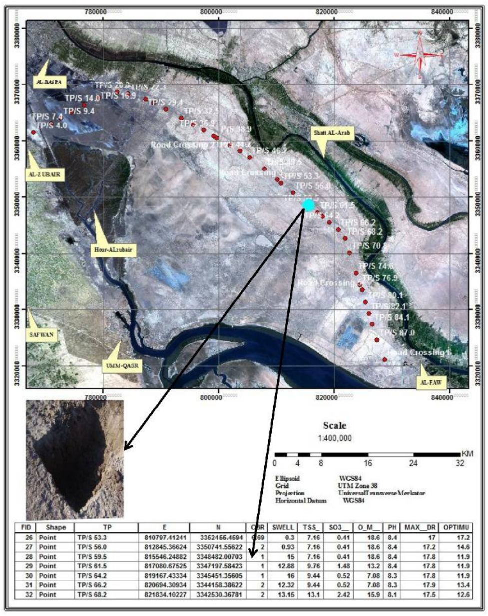


Figure 5: Connect Digital Image to Other Borehole Exist in the Study Area by Using ARCGIS9.2

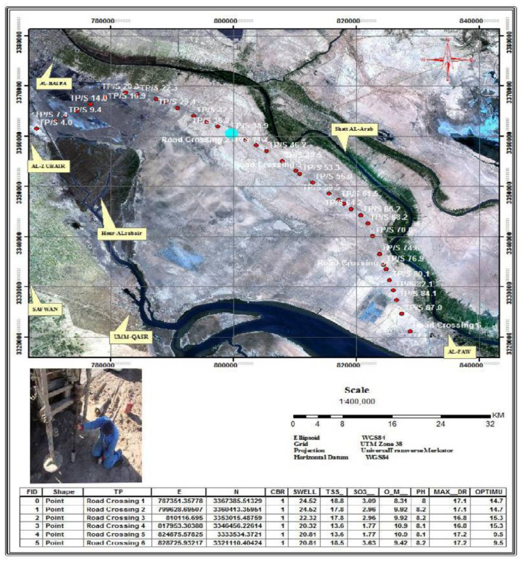


Figure 6: Connect Digital image to Road Core Borehole Exist in the Study Area by using ARCGIS9.2

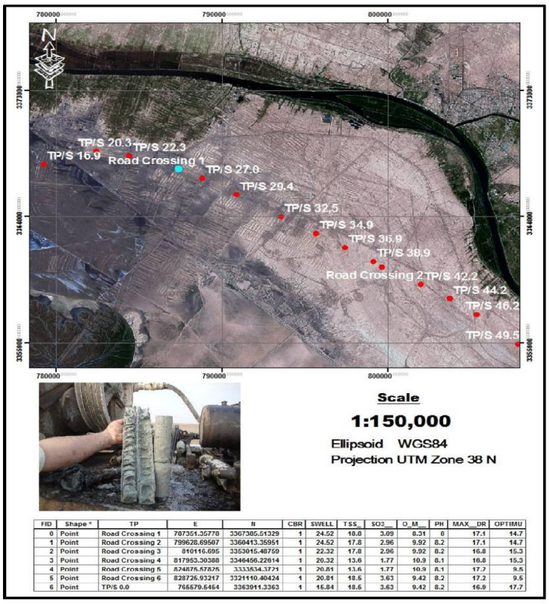
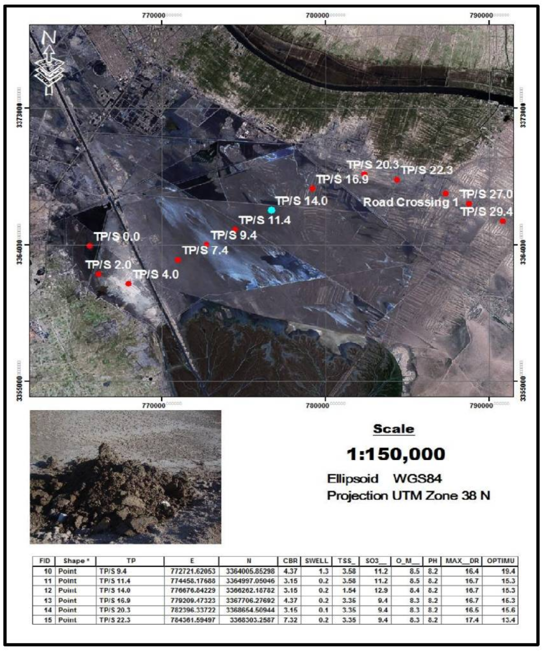


Figure 7: Connect Attribute Data to Road Core Borehole Exist in the Study Area by using ARCGIS9.2



program. After the selection of the satellite image, the next step is preparing the limitation of the case study and the location of samples. The mentioned data can be converted easily into vector format.

The GIS data inputs include the points which applied in this research. The point data collection include qualitative descriptions of the location coordinates (easting, northing) that observed by GPS survey . The control points are selected in the input raster dataset and the output locations are specified by typing in the known output coordinates (ESRI, 2007). The steps are followed to enter these points locations into ArcGIS v.9.2 package, which is a professional GIS level from (ESRI), and they are determined on the study satellite imagery, and the data have been used in this research, includes the database that has been constructed from digitizing using this information. All these data have been made by transforming from raster form to vector form.

CBR PREDICTION MODEL

Five Different fine grained soils were collected from different zone of Al Basrah city (60 samples from Al-zubar to Al-faw). Preliminary laboratory tests, such as grain size distribution, LL and PL were conducted in accordance with AASHTO specification. Table 1 summarizes index properties and classification of the soils. Table 1 Properties of Different Types of Soils from different Zone of Al Basrah city.

The modified proctor procedure was used to prepare CBR samples. The compaction efforts used in present study were: 56 blows, while the moisture level were at OMC. Each CBR sample was compacted in five layers of soil using predetermined number of blows and water content. A total of 60 soil samples were prepared for CBR testing for socked and unsoaked soils. Soaked and unsoaked CBR models were developed considering various independent variables: swell index, optimum moisture content, maximum dry density, PH value, SO_3% content and TSS% contents:

Soaked CBR Model

CBR soak = 99.70867-0.27925*

SWELL% + 0.307435* TSS%

+ 0.17726 * SO3_% + 0.104973 *

O_M_% – 13.5941* PH

+ 0.723558 *?MAX_DR

+ 0.15879 *?OPTIMU ...(1)

$R = 0.91901646$ $R^2 = 0.84459125$

Unsoaked CBR Mode

CBR model = –56.0895 – 0.21345

* SWELL – 0.05313 * TSS%

–0.17681* SO3_% –0.10569 *

O_M_%-0.44586 * PH

+ 3.795873*?MAX–DR

+ 0.227032*?OPTIMU ...(2)

$R = 0.93540016$ $R^2 = 0.87497346$

where

CBR	Bearing Capasity Rat
SWELL	Swelling
TSS	Shear Strength Tester
SO_3	Sulfate Ion
O_M	Chemical Test
pH	Hydronium Ion
MAX_DR	Maximum dry density
OPTIMU	Optimum Moisture content

Validation Results

The half of the observed data (those not used in the development process), is used in the validation process of the Soaked and Unsoaked CBR_models. The observed Soak and Unsoaked CBR_model values are plotted against those obtained by using of the developed model. This comparison is presented in Figures 8 and 9 below.

Figure 8: Predict Model vs Observed Model in Soaked CBR Model

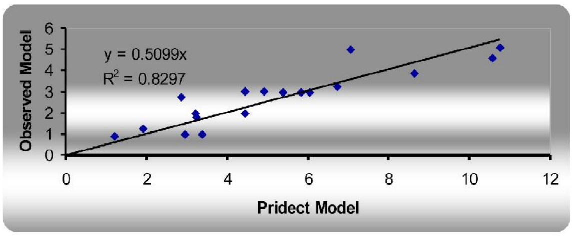
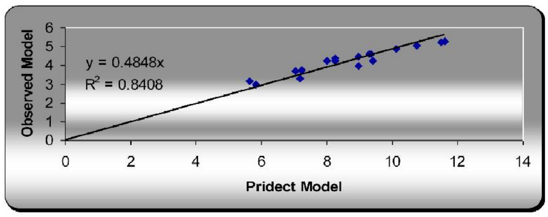


Figure 9: Predict Model vs Observed Model in Unsoaked CBR Mode



The best fit of the relation between observed and estimate tensile strength can be found in the following form:

CBR Soak Observed = 0.5099
* Estimated CBR Soak ... $R^2 = 0.8297$ ...(3)

CBR UnSoak Observed = 0.4848
* Estimated CBR UnSoak ...
$R^2 = 0.8408$ ...(4)

These finding seem to be in good agreement with the relation $y = x$ .The results of checking the goodness of fit for the estimate CBR soaked and unsoaked modeles and observed models by using chi-square test . this testing can be seen in the following paragraph.

Goodness of Fit

Chi-squire – test

X2 –test

N = 15 df =14 confidence level = 95%

Variable	χ^2-value	X_c^2 -value
X = Observed	30.14	20.49620
Y= Predicted Soaked and Unsoaked models		

For $X^2 < X_c^2$ .Thus is no significant different between the observed and the predicted value.

DISCUSSION

Models to estimate soaked and unsoaked CBR values of fine grained subgrade soils of Al Basrah city are developed using regression technique Multiple Linear Regression (MLR) using STATISTICA 5.4 software.

A total of 60 samples were tested for soaked and unsoaked CBR values for five different soils. Regression-based models were developed and validated. A good agreement was observed between the measured and the predicted CBR values, as shown.

Furthermore, it was observed that the CBR value, both soaked and unsoaked significantly affected by change in moisture content and. The effect of both moisture and maximum dry density is more significant on the CBR value.

CONCLUSION

1-In this research five different fine grained soils were collected from different zone of Al Basrah city (60 samples from Al-zubar to Al-faw). Preliminary laboratory tests, such as grain size distribution, LL, and PL were conducted in accordance with AASHTO specification. A total of 60 soil samples were prepared for CBR testing for socked and unsoaked soils. Soaked and unsoaked CBR models were developed considering various independent variables: Swell index, optimum moisture content, maximum dry density, pH value, SO_3 % content and TSS% contents. It can be concluded that the CBR value, both soaked and unsoaked significantly affected by change in moisture content and. The effect of both moisture and maximum dry density is more significant on the CBR value.

Soaked CBR Model

CBR soak =99.70867 – 0.27925* SWEEL% + 0.307435* TSS% + 0.17726 * SO_3_% + 0.104973 * O_M_% – 13.5941* PH + 0.723558 * ?MAX–DR +0.15879 *?OPTIMU

$R = 0.91901646$ $R^2 = 0.84459125$

Unsoaked CBR Model

CBR model = 56.0895 – 0.21345
* SWELL – 0.05313 * TSS%
– 0.17681* SO_3_% – 0.10569 *
O_M_% –0.44586 * PH
+ 3.795873*?MAX_DR
+ 0.227032*?OPTIMU

$R = 0.93540016$ $R^2 = 0.87497346$

2-Using GIS technique is very important to produce digital thematic maps that show the land cover in the study area. Also Using GPS in field survey is very essential and important for positioning purposes, and collecting soil samples.

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APPENDIX

Etrex GPS