MSc Theses Abstract

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Graduation Year 2004

Thesis Title: **GEOTECHNICAL PROPERTIES OF AN ORGANIC DEPOSIT AT KOPUNDOL, KATHMANDU VALLEY**

Submitted by: **Ramesh Neupane**

Supervisor: **Padma Khadka and Dr. S. Hundali**

ABSTRACT:

A study on the geotechnical properties of an organic deposit of Kathmandu Valley, namely at the bank of Bagmati River, near the Bagmati Bridge in Kopundol, Patan was conducted experimentally in the laboratory. Laboratory tests were carried out on disturbed and undisturbed samples taken from a single borehole drilled to 11 m. The investigation included the index properties of the soil, swelling, compaction and consolidation characteristics for different depth of samples. The effect of sample preparation methods, namely oven-dried, air-dried and natural states of the Atterberg limits and compaction characteristics were also studied. Long term settlement study was carried out on sample from one depth subjected to load less than the effective overburden pressure as well as that exceeding the effective overburden pressure.

The organic content of the soil was found to increase with depth and varied between 8.3 % and 13.1 %. Increasing organic content with depth was accompanied by decreasing specific gravity, increasing Atterberg limits and increasing free swell with depth, suggesting the effect of organic content on these properties. Drying methods have a strong effect on the Atterberg limits and compaction characteristics, leading to a conclusion that these tests should be done on naturally prepared samples without pre-drying. The swelling potential estimated indirectly from the different soil properties shows conflicting signals, i.e., some showing high swelling potential while other indications suggest low potential. The consolidation tests showed high compressive index in the region of 1.05 to 1.20 while long term consolidation tests reveal a peculiar pattern of settlement with time curve that do not match with standard consolidation curve. The tests also reveal significant long term compression compared to the standard 24 hour duration settlement normally used in consolidation tests to obtain primary consolidation settlement.

Thesis Title: **EXPERIMENTAL AND NUMERICAL ANALYSIS OF DYNAMIC BEHAVIOUR OF SOIL AND FOUNDATION SYSTEM**

Submitted by: **Mohan Prasad Acharya**

ABSTRACT:

This study is mainly concentrated to the deformation analysis of soil due to dynamic loading condition. The study is based on the simple two-dimensional studies of soil and loading arrangement simulating the case of shallow foundation at different types of earthquakes. The work is based on through study of dynamic behavior soft soil including the methodology of determination of input parameters for dynamic analysis. The available material models to include the non-linearity of soil are fully described. Experiments to measure the deformation on dynamic loading are done with the verification of result from numerical finite element model. Finally a simple independent footing over a thick elastic clay block is modeled to get the time domain analysis of deformation at the soil structure interface.

A recently developed methodology PIV (Particle image velocimetry) is used to measure the transient deformation on soil due to dynamic loading like impact. Very high velocity digital cameras are used to capture the movement within fracture of seconds, nearly 1000 frame per second, than displacement

between each consecutive image is analyzed by using PIV software; PIV Sleuth. The un- imaginable elastic rebound of sand body at transient loading can be seen directly with open eyes between two image frame and is verified by the displacement calculated using PIV Sleutlh.

Later the sand displacement is modeled using finite element soft ware LUSAS to verify the experimental results. The sand body is modeled as an elastic spring body, a elastic body with damping, a elastic and perfectly plastic Mohr coulomb material model and a elastic-plastic Mohr- Coulomb material model with strain hardening. It is found that the sand body before failure works similar to the elastic spring system with certain structural damping. The change in response with the variation of density and thus damping of sand body is clearly seen during the LUSAS analysis.

PIV analysis, though generally used in fluid mechanics is found to be effective to capture the micro deformation at surfaces of structures. It is possible to study the failure pattern of different type of soil and foundation from a small experimental model and finally calculate the bearing capacity both effectively and economically. The dynamic response analysis of shallow footing shows high amplitude displacement and amplification on soft soils. Though the result is satisfactory more study is necessary to

correctly model the foundation, free of structure and free to move at bottom.

Thesis Title: **EVALUATION OF CONSTRUCTION METHOD OF TUNNEL IN CHILIME HYDRO-ELECTRIC POWER PROJECT, RASUWA, NEPAL**

Submitted by: **Vijay Kumar Mahato**

Supervisor: **Prof. Dr. A. B. Singh**

ABSTRACT:

The study on 'Evaluation of construction method of tunnel in Chilime Hydro-power Project, Rasuwa, Nepal' is carried out in two parts: in the first part, the analysis of rock mass classification is carried out for the headrace tunnel. The analysis of the rock mass classification includes both the RMR classification system and the Q system of classification. The headrace tunnel considered here is composed of five types of rock masses classified according to the Q system. These are II type (Good), III type (Fair), IV type (Poor), V type (Very Poor), VI type (Extremely Poor). Out of 2357 meters headrace tunnel, 2.09% is of good quality, 24.50% is of fair quality, 37.43% is of poor quality, 21.21% is of very poor quality, 14.87% is of extremely poor quality rock mass. Most of rock masses in headrace tunnel composed of fair and poor quality of rock. The Q system of rock mass classification has been adopted for further analysis of blast cycle and tunnel support system. In second part of the study a relationship between different components of blast cycle and

rock type is established. Different parameters of blast cycles are calculated for three hundred and fifty six blast cycles in upstream side and five hundred six blast cycles in downstream side. The thesis also includes the review of the excavation methods i.e. blasting techniques of Surge tank, Penstock of the Chilime hydropower project.

Thesis Title: **STRESS - STRAIN AND STRENGTH BEHAVIOUR OF ORGANIC SOIL AT KOPUNDOL, KATHMANDU VALLEY UNDER UNDRAINED CONDITION**

Submitted by: **Sujit Dhital**

Supervisor: **Padma Khadka and Dr. S. Hundali**

ABSTRACT:

A series of static triaxial test were done on the undisturbed sample of Organic deposit taken from a bore hole drilled to 11 m. depth at the left bank of Bagmati River, down stream of the Bagmati Bridge at Kopundol of Lalitpur Sub metropolitan city in Kathmandu Valley. These undisturbed samples were consolidated isotropically under different confining pressure but sheared under undrained condition. Unconsolidated undrained tests were performed on samples taken from depth interval of 1m to obtained the undrained shear strength profile upto the bore hole depth. Samples taken from depth of 4.5m -5.5m interval were subjected to different consolidation pressure to determine the overconsolidation and normally consolidation failure envelope as well as the stress -strain and pore pressure characteristic. Another series of the test from the same deposit was performed on samples brought to different overconsolidation

ratio but having the same void ratio to observe the change of behaviour of soil due to OCR at constant void ratio.

Samples that were shear with in the normally consolidated range of cell pressures were found to behave in the normalised manner. The value of the deviator stress was found to increase with the increase of the cell pressure. The strains at which the samples failed were found to decrease with the increase of cell pressure. The relationship between the stress ratio and the pore pressure in the normally consolidated samples were found to be almost linear similar to that found in some other soil.

Sample sheared at different overconsolidation ratio but at the same void ratio shows the lower strength with higher overconsolidation ratio. Similarly the strain at which the deviator stress attain the maximum value decrease with increase OCR. The second portion of bilinear line of pore pressure and stress ratio of the overconsolidated samples was found to be parallel to that of normally consolidated sample.

The undrained shear strength varies more or less in a linear pattern with the depth. The normalised shear strength with respect to overburden pressure was also found to vary linearly with the plasticity index of the soil. A linear relation equation correlating su/σ_{vo} with plasticity index was proposed for the soil, which appear to be different from that proposed by Skempton

The stress path and stress- strain of normally consolidated samples with some critical state models namely Cam Clay Model, Modified Cam Clay Model, Fender Model and model based on linear pore pressure -stress ratio developed by Handali (1986). A simple model was developed by Author using Kondner (1963) hyperbolic relation and the linear pore pressure strain ratio respectively. This model was found to predict the stress-strain curve in reasonably close to the test data.

Thesis Title: **GEOTECHNICAL STUDIES ON POWER TUNNEL OF MIDDLE MARSYANGDI HYDRO ELECTRIC PROJECT LAMJUNG NEPAL**

Submitted by: **Atma Ram Khanal**

Supervisor: **Prof. Dr. A. B. Singh**

ABSTRACT:

Middle Marsyangdi Hydroelectric Project is a run of river type of project, located in Lesser Himalayas in Lamjung District Nepal. The geotechnical/geological condition of power tunnel of Middle Marshyangdi Hydroelectric project were evaluated on the basis of existing reports on investigation and conducting field mapping and laboratory rock tests. Engineering geological mapping along the tunnel alignment was earned out which helped classify the rock mass quality according to most popular classification, namely RMR and Q system. The RMR values thus obtained show 3.46% of fair rock, 5.97% of good rock, 29.05% of fair-good rock, 40.47% of fair rock, 15.13% of poor rock and 5.92% of very poor rock along the headrace tunnel The determination rock mass properties like point load strength; uniaxial compressive strength, etc were can-led out to aid the assignment of rock mass quality. The result from this study indicates that the rock mass quality along the tunnel may range from very poor to good rock. From the comparison of rock mass parameter it is

found that the result obtained from construction is less than the result obtained from feasibility and present study. This variation is mainly due to the fact that during the feasibility and present study stage, the rock mass properties are calculated on the basis of outcrop data. The outcrop is generally covered by bushes, trees and overburden soil. So it is difficult to predict exact rock mass properties on the basis of outcrop data. The variation may also due to the region of counting rupture as joint sets during face mapping of the tunnel, some mechanical breakage may also be counted as natural breakage and variation of ground water condition.

Thesis Title: **DESIGN OF SUPPORT SYSTEM IN MIDDLE MARSYANGDI POWER TUNNEL**

Submitted by: **Binod Shrestha**

Supervisor: **Prof. Dr. A. B. Singh**

ABSTRACT:

The design of support systems is much more an art than a science. The principal objective in the design of the underground excavation support is to help the rock mass to support itself. Selection and design of support systems are only two of many inter-related factors in the overall design of serviceable and economical tunnel. An investigation of the cost associated with the tunnel in rock indicates that the combined support and lining system represents *1/4* to *1/2* of the total cost of project. It is obvious that major savings may be recognized by even slight improvement of design of the tunnel support and lining systems. In Nepal hydropower is recognized as white gold which can play significant role for the development of nation. Middle Marsyangdi Hydro Electric Project (MMHEP) is the largest on going project of Nepal. The power tunnel of this Project has been considered for study of this research whose objective is to carry out the comparative analysis of support system used in MMHEP. Besides this, the study is also focused in selection of support system considering rock support interaction.

Based on the collected field data on existing support system, an analysis was carried out with the values obtained from RSR, RMR and Q methods, determined separately for five sections of the tunnel. A Computer Program has been developed for the interaction analysis of Rock Support system using Visual Basic Program.

From this research, it is found that the correlation between RMR and Q-value is RMR = 71nQ + 45, relation between RSR and Q is RSR = 9.651nQ + 8.71 and that of RSR and RMR is RSR = 1.04 RMR + 13.45 for this study area. Although the relationship obtained in this study is slightly different from their relationship developed by Bieniawski, Rutlegde and Preston, a good relationship is observed between these methods. Comparison of three empirical support design methods, RSR, RMR and NGI-Q system related to Middle Marsyandi Power tunnel implies that the Q-system is the most flexible one in application for local variations of rock conditions.

The study has recommended that the rock support system should be designed by NGI-Q system for the geological condition similar to Middle Marsyandi Power Tunnel. An interaction analysis should be carried out in order to justify the results obtained from Q system to ensure cost effectiveness and safety.

Thesis Title: **SLOPE MASS RASTING AND THEIR INSTABILITIES: A CASE STUDY ALONG NARAYANGHAT- MUGLING ROAD**

Submitted by: **Biplab Kumar Ghimire**

Supervisor: **Dr. I. R. Humagain**

ABSTRACT:

Slope mass quality has tremendous effect on Hill Slope Instabilities. So the rating of the slope mass is very essential prior to the stabilization measures and risk analysis. Narayanghat-Mugling road Sector is studied as the model site .The aspects of the problems addressed are on the basis of Slope Mass Rating (SMR) System. SMR values are based on the Rock Mass characterization proposed by Bineaswaski. Rock Mass Rating System is performed on the basis of discontinuities, seepage conditions, weathering grade slope aspects and Geotechnical studies. Engineering geological study, hydrological studies and geophysical Studies are also performed for the better performance of SMR.

For the prediction of failure mode (plane failure, wedge failure, toppling failure) a computer based graphical program called DIPS has been used. Slope Mass Rating system including Geotechnical studies are used to predict the high vulnerable, vulnerable, less vulnerable and stable slope. The value of RMR

and SMR are found within 0 to 62 and 24 to 80 respectively during analysis.

The study concludes that that the failure of slope is caused due to joint water hammering in highly jointed rock mass. Similarly high grade of weathering, presence of discontinuities, worst seepage condition and improper drainage system are the major causes of slope instabilities along Narayangaht -Mugling road.

Thesis Title: **ON THE RESILIENT CHARACTERISTICS OF BAGMATI AND MANAHARA RIVER SAND**

Submitted by: **Dinesh Singh Maharjan**

Supervisor: **Padma Khadka and Kaushal K. Jha**

ABSTRACT:

Resilient modulus is one of the important parameters for the modeling of granular material and mechanistic design of flexible pavement. It is generally determined from the repeated triaxial test of sample of granular materials. The magnitude of the resilient modulus of sand depends on several factors such as initial void ratio, initial confining stress and grain size composition among others. In this study, it has been found that the effect of initial confining stress and initial void ratio affect the magnitude of resilient modulus significantly. It is investigated that resilient modulus increases with the increase in void ratio for the same initial confining stress. For the same initial void ratio, the magnitude of resilient modulus also increases with the increase of initial confining stress.

In order to compute the resilient modulus from K-θ test, the material constants pertaining to the Bagmati and Manahara river sands are established in this study. Resilient modulus can also be computed from CBR test. But it is concluded in this study that CBR test overestimates the value of resilient modulus of sand.

In order to reflect the effect of grain size composition on the resilient modulus of sand, an empirical relationship correlating void ratio range and resilient modulus is established. It is investigated that the resilient modulus decreases with the increase in the void ratio range.

Thesis Title: **ANALYSIS OF INCREASE IN SHEAR STRENGTH OF SOIL AFTER THE IMPLEMENTATION OF SOIL BIOENGINEERING TECHNIQUES**

Submitted by: **Sajan Tuladhar**

Supervisor: **Padma Khadka**

ABSTRACT:

Landslide is one of the natural hazards, which causes lots of damages in Nepal. Different methods of stabilization are currently practised, among them soil reinforcement with tree roots is one. The roots increase the shear strength of soil by transmitting developed shear stress to tension strength. The additional strength created by roots is known as the growing cohesion, which increases with vertical stress and area occupied by the roots. In this research, an attempt was made to study the effect of root of *Thysanolaena maxima* and *Salix tetrasperma* at Thankot. Large scale-in-situ direct shear tests were carried out on both rooted and rootless soils. The occupied root area was calculated by counting the number and measuring the diameter of effective roots within the shear zone. The results show an increase of 46% in shear strength in both *Thysanolaena maxima* and *Salix tetrasperma* in maturity period of 4 years.

In addition, the plant growth performance were observed to determine the increase in shear strength of the rooted soil, by

measuring shoot growth above the ground on different plant species that were planted by Leiter Lukas in winter of December 2000. It is important to notice that the Department of Roads HMG (His Majesty's Government of Nepal) has common practice to carry out soil bioengineering works in June, just before the monsoon rains.

The shining of the plantation and construction does allow the plants to set up rooting system already before the monsoon time, the loose soil material will be consolidated thus ensuring an increased safety factor of the slopes. In addition the shifted implementation time into winter can generate vital off-farm employment opportunities.

In this study, the observation of the species on the plot established by Leiter Lukas was continued and found that *Salix tetrasperma* used as cuttings are found to be highly suitable for the construction of fascines and palisades.

Thesis Title: **STRENGTH AND DEFORMATION CHARACTERISTICS OF BAGMATI RIVER SAND BASED ON STEADY STATE CONCEPT**

Submitted by: **Sanjay Kumar Jha**

Supervisor: **Padma Khadka and Dr. S. Hundali**

ABSTRACT:

The steady state line of Bagmati river sand has been determined in this research from both the empirical relationship and from triaxial tests. Results from both methods show very good correlation. The steady state strength envelope of Bagmati sand has also been drawn from triaxial test results and it has been found that friction angle mobilized at steady state in case of Bagmati sand is 34°. The dependency of steady state line with mean diameter 050, maximum and minimum void ratios has also been studied in this research. Since the steady state line can be used for evaluation of liquefaction potential along with other characteristics of sand, this research will be useful for mitigation of liquefaction.

On the other hand, the present research on Bagmati river sand explains basic engineering properties: grain size distribution, specific gravity, maximum and minimum void ratios along with its mineralogical composition. The research mainly describes the drained and undrained behavior of Bagmati river sand under

different conditions of initial density and initial confining stress which will be extremely useful for determining strength and deformation characteristics of sand. Also the further analysis is based on a well known and proven steady state theory.

The steady state line has been used for modeling of drained behavior of the sand. The modeling results are quite satisfactory and match with experimental results with little variation. Since the steady state line can be obtained from maximum and minimum void ratio differences which can be obtained from mean effective diameter D_{50}. is concluded that if the mean diameter of the sand and the grain shape of the sand is known, the drained behavior can be determined from the model without doing complex and costly triaxial tests.

Thesis Title: **STRUCTURAL PERFORMANCE OF LIME STABILIZE SUB-GRADE SOIL IN FLEXIBLE PAVEMENT DESIGN**

Submitted by: **Sanoj Kumar Bhattarai**

Supervisor: **Keshav Kumar Amatya**

ABSTRACT:

The current practice in road construction in Kathmandu valley is known by imported filling material to prepare a relatively stable sub-grade layer for construction of pavement structure over poor in-situ sub-grade soil. This practice is very common in Nepal where the poor sub-grade soil is encountered.

This thesis presents a direct evaluation of the optimum lime content for treatment of fine grained soil which is regarded as a sub-grade soil for laying flexible pavement layers. This research aims the assessment of road sub-grades based on lime stabilization, against poorer foundation of sub-grade soils for the flexible pavement design, as well as investigation and the evaluation of engineering and structural properties of the stabilize sub-grade soils, to see the performance characteristics in the flexible pavements.

Over ten lab tests were conducted in in-situ samples and samples treated with different percentages of quick lime were also

subjected to similar laboratory tests and the optimum lime content was determined.

The test results indicated that the addition of lime is effective up to 3%, after which it starts to give a reverse effects on the strength characteristics of the tested soil. The strength percentage of 3% lime treated soil was 2.75 times that of the untreated soil and about 2 times that of the untreated soil for 5% lime content. The findings result shows that above 3% of lime addition do not contribute in upgrading the strength characteristics of the sub-grade soil. The extra lime content more than the optimum is presented in the form of free lime. The delay time on the compaction of soil-lime mixture was found to reduce the strength in considerable level, because of the carbonization of the lime occurred in the free air. A new parameter termed as Lime Treatment Strength Ratio (LTSR) is introduced and used for characterizing the effectiveness of lime treatment for forecasting the strength of natural in-situ soil, after lime stabilization.

The 3% lime used for the soil-lime mixture is found optimum for sample in situ inorganic fine grained soil (ML), which is usually verified by the results of consistency indices, pH value, unconfined compressive strength results and the consecutive results obtained from the mechanical properties of the soil-lime mixtures.

In the second part, the design of the flexible pavement has been considered based on the optimum 3% lime stabilization to the natural soil, is proved that the cost optimization is in the significant order. The cost effectiveness of 3% lime in the road construction is 20 % that of the natural soil. This is due' to the higher performance of the sub-grade soil in response to the traffic wheel load. Although this value is small in comparison but it results in large savings especially in large investment road construction projects.

Therefore, it can be concluded that the lime stabilization would be one of the option in order to improve the strength of the in-situ sub grade soil, as the practice of stabilization is not common in Nepal.

Thesis Title: **LANDSLIDE HAZARD MAPPING OF NAGADHUNGA-NAUBISE SECTION OF TRIBHUVAN HIGHWAY WITH GIS APPLICATION**

Submitted by: **Arjun Raj Pandey**

Supervisor: **Padma Khadka**

ABSTRACT:

The location of study area is Nagdhunga-Naubise, a section of Tribhuvan Highway. This lies in the Middle Mountain region of Nepal. As in the title of thesis the aim is to prepare a hazard map of Nagdhunga-Naubise section. For the preparation of the hazard map of the corridor three steps; initial study, field investigation, and data analysis and presentation were carried out.

In initial study, collection of secondary data and review of the literature were done. The base map was then prepared from topographical map. From the field investigation, all information and maps prepared earlier in the desk study were verified by field check. The data prepared and verified were then analyzed for the hazard mapping. Topography (gradient, slope shape and slope aspect), geology, drainage and landuse were considered to be the major influencing factors in the slope stability. **Pre-assigned hazard rating method** is used for hazard mapping of the study area. The area is divided into equal facets, the ratings of

responsible factors to the hazard are then assigned to each facet and overlay based upon a predetermined rating scheme. Then total estimated hazard is the sum of these ratings for each overlay. Then hazard map is prepared by using three categories as **low hazard, medium hazard** and **high hazard.** The Geographic Information System (GIS) was the main tool for the data input, analysis, and preparing final hazard map.

The hazard map showed the areas of different hazard potential class "low" with 32% portion "Medium" the most found with a portion of about 51% and the class "high" with the portion of 17%.

The first part of the thesis describes the biophysical background of Nepal and discusses general aspects of slope instability. The second part includes the methodology to accomplish the landslide hazard map followed by findings and conclusion.

Graduation Year 2005

Thesis Title: **ANALYSIS OF SUPPORT SYSTEM IN THE HEADRACE TUNNEL OF CHILEME HYDRO-ELECTRIC PROJECT**

Submitted by: **Raj Narayan Yadav**

Supervisor: **Prof. Dr. A. B. Singh**

ABSTRACT:

Based on the data obtained from Chilime Hydropower Company Pvt. Ltd. the study on **"Analysis of Support System in the Headrace Tunnel of Chilime Hydro-electric Project"** has carried out in two parts. In the first part, analysis of support system has been done by empirical methods. RMR and Q-system has been used to classify the rock mass. Stand up time has been calculated from RMR value and types of support systems have been informed by Q-value. The headrace tunnel (length=2826.5m) consists of five different types of rock mass classification such as i) Good ii) Fair iii) Poor iv) Very poor v) Extremely poor in which 2.09 % is of good quality, 24.05% is of fair quality, 37.43% is of poor quality, 21.21% if of V.P quality, 14.87% is of extremely Poor quality rock mass.

In the second part, the design of support system has done by analytical method, considering rock support iteration analysis.

The total length of headrace tunnel is 2826m. The whole length of tunnel has been divided into six parts with respect to rock cover. Individual analysis has been done for each rock cover. Rocks are found in the interbedded form of quartzite and schist. So as per rock mass classification six types (three for quartzite and three for schist) of analysis has been done for each rock cover.

The study has concluded that immediate support is needed throughout the Headrace tunnel. Though the empirical method shows that tunnel can stand without any support for every rock cover except 260m rock cover having Poor rock mass classification, at least 5cm shotcrete has to be provided for safety point of view. The thesis includes the comparison of support system provided in Head race tunnel of Chilime Hydroelectric Project.

Thesis Title: **EFFECT OF ADDITIVES ON ENGINEERING PROPERTIES OF LOW ORGANIC SOIL AT KATHMANDU**

Submitted by: **Renu Bishwas**

Supervisor: **Padma Khadka and Dr. S. Hundali**

ABSTRACT:

This research describes a study on the effect of cement, lime and fly ash additives on the engineering characteristics of a fine grained soil with a slight organic content at Teku, Kathmandu. Harvard Miniature compaction apparatus was used to determine the compaction characteristics and unconfined compression test was carried out to determine the strength of samples subjected to prior immersion and without immersion. Ordinary Portland cement, commercially available quick lime and fly ash, namely pozzocrete, were used. The amounts of cement and lime added to the soil sample as percentage of the dry soil mass were in the range of 3-7 % and fly ash was in the range of 3-28 %, respectively.

The results of the study show that the addition of the chemical additive, can improve the engineering properties of the soil under study despite of its slight organic nature. The soil maximum dry unit weight is found to decrease while the optimum water content is found to increase with increase in the cement, lime and fly ash

content. The addition of 7 % lime reduced the maximum dry unit weight by as much as 8.9 % and increased the optimum moisture content of untreated soil by as much as 19.1 %.

When comparing the performance of the cement and lime as additive for this soil, the ordinary Portland cement appears to perform better than the quick lime. Compared to untreated soil the maximum increase in strength for sample with 7 % lime without pre-immersion in water after 60 days curing is 6.5 times. The soil with 7 % cement shows maximum increase in strength by 6.8 times after 60 days curing without immersion in water. Immersion has been found to greatly reduce the strength of the treated soil in all cases. The worst deterioration has been observed in fly ash treated soil. While quick lime shows the existence of optimum lime content of 5 % to produce higher strength for low curing time, cement shows a linearly increasing strength with increasing cement content at almost all curing times. The addition of fly ash to lime eliminates the optimum value observed in the samples treated by lime only but no higher gain in strength was observed compared to adding lime only. In all cases increasing curing time results in increasing strength. In most cases the largest portion of strength gain happened during the first 7 day period.

Thesis Title: **COMPARATIVE STUDY OF CONSTRUCTIVE RELATIONSHIPS FOR DRAINED MODELING OF BAGMATI RIVER SAND**

Submitted by: **Sanjay Kumar Karn**

Supervisor: **Padma Khadka and Kaushal K. Jha**

ABSTRACT:

A comparative study of different constitutive models able to predict drained sand behavior have been carried out in this thesis. Comparisons have been made within the frame work defined by characteristic states of sand. These characteristic states include steady state line, quasi steady state line, upper reference line etc. A steady state line for Bagmati river sand is found out in this study. The apparent positions of steady state line in the e - p diagram for Bagmati river sand has been established by both emperical relationship and by drained test.

Simulation of sand behavior via state concept requires some index parameters such as state index, state parameter and state pressure index. These parameters have ability to quantify the combined influence of initial void ratio and initial confining stress on the behavior of sand. However, these basic definitions are different. State Index, in general, is defined with respect to quasi steady state line and upper reference line. But in case of undisturbed sample, one may not obtain quasi steady state line.

In this study, steady state line has been used for the computation of state index.

It has been found in the literature that state index and parameter of stress strain curve has linear correlation. A similar corrrelation between state parameter and parameter of stress strain curve and between state pressure index and parameters of stress strain curve have been established in this study. It has been found that parameters of stress strain curve decrease as the state parameter increases. However, the nature of variation is linear. In case of state pressure index, the variation is not linear. Yet a unique correlation between them have been established.

The state parameters discussed above can be readily obtained once steady state line and upper reference line are known. Keeping the simulation procedure same, all of the three parameters have been employed. It has been found that all these parameters are able to model the drained sand behavior with reasonable accuracy. Thus a unified computer program has been developed which simulates the drained stress strain behavior depending upon the availability of characteristic states.

Provost and Duncan model can simulate strain hardening behavior more accurately. For strain softening behavior, the performance of these models is not satisfactory.

Thesis Title: **STOCHASTIC MODELING OF PROGRESSIVE FAILURE IN HETEROGENEOUS SOIL SLOPE**

Submitted by: **Dhundi Raj Pathak**

Supervisor: **Prof. Dr. A. B. Singh and H. N. Gharti**

ABSTRACT:

Accurate and efficient simulation of the slope stability, certainly gives the reliable approach for the hazard preparedness. However, inherent difficulties associated with the slope failure make the situation very difficult. First, the computation of fracture path based on the strict mathematical formalism is cumbersome especially for the progressive fracture phenomenon. Second, due to the lack of reliable knowledge on material properties, stochastic simulation is necessary. Stochastic modeling together with the progressive fracture phenomenon is apparently difficult task. In this thesis, heterogeneous slope is simulated considering the progressive fracture phenomenon using the modified finite element method. This numerical technique introduces the fracture along the edge of the meshes thus incorporating the time evolution of the fracture surface. This is achieved by restructuring the tessellation in every fracture stage. Unlike remeshing this technique only increases the number of total nodes while number of meshes remaining same. In this way the fracture treatment in this technique is simple and natural.

Initially, the slope has been analyzed by considering homogeneous slope materials in dry condition for the rigorous check of this numerical technique and then performed effective stress analysis considering effective stress parameters. It also deals with the stratification and spatial heterogeneity of the soil slope. The results show the expected nature of the factor safety with respect to the progressive nature of the fracture. The results obtained from this numerical technique is compared with value obtained from slope stability charts and found to be more efficient and reliable numerical technique for slope stability analysis.

Further, in this thesis, effect of uncertainty in the material properties upon the uncertainty in the response of soil slope has been evaluated, hence giving the reliable probabilistic estimation of the factor of safety, failure surface and deformation of the slope. In this research, it has been found that the effect of materials heterogeneity is crucial in slope stability analysis. Hence, the simulation based on the more reliable understanding of the material properties and the efficient numerical procedure for the progressive fracture phenomenon can give the reliable result of the simulation for the heterogeneous soil slope thus enabling the more accurate way for hazard preparedness.

Thesis Title: **GEOTECHNICAL PROPERTIES OF SOME ORGANIC DEPOSITS IN KATHMANDU VALLEY**

Submitted by: **Him Bandhu Upadhyay**

Supervisor: **Prof. Dr. R. K. Poudel, Padma Khadka and Dr. S. Hundali**

ABSTRACT:

A study on the geotechnical properties of organic deposits of Kathmandu Valley, namely at Kalimati and Kirtipur was conducted experimentally in the laboratory. The borehole drilled in Kalimati was of 25 m and that for Kirtipur was of 10 m. The investigation included the index properties, organic content, free swell, consolidation and unconsolidated undrained tests.

Organic content in Kalimati and Kirtipur were in the range of 4.94 - 12.09 % and 4.42 - 9.03 %, respectively and were found to increase with depth. Specific gravity, bulk density and dry density were generally found to decrease with depth. Increase in organic content results in the decrease of specific gravity, bulk density and dry density and increase in void ratio, water content, liquid limit, plasticity index and compression index. The consolidation tests showed that all the samples showed overconsolidation behavior except at 6 m and 10 m of Kalimati and Kirtipur site, respectively. High compression index up to 1.23 in Kirtipur and 1.19 in Kalimati were observed. The long

term settlement test reveals that the settlement in secondary consolidation was significant in proportion to primary consolidation settlement. Unconsolidated undrained tests showed a peculiar pattern of stress - strain curve in that two strength peaks exists, the first presumably belongs to breaking of the original structure of the soil.

Thesis Title: **GEOTECHNICAL PROPERTIES OF RED RESIDUAL SOILS DEPOSIT AT SANGA, KAVRE**

Submitted by: **Santosh Kumar Yadav**

Supervisor: **Prof. Dr. R. K. Poudel, Padma Khadka and Dr. S. Hundali**

ABSTRACT:

A Study on the geotechnical properties of red residual soil deposits of Bhainsepati, Sanga - 1, Kavre district, near by Kathmandu Valley was conducted. Laboratory tests were carried out on disturbed and undisturbed samples taken from a single borehole drilled up to 9.5m. The investigation includes the index properties of the soil, unconfined compressive strength, compression characteristics and swelling potential and swelling pressure for different depths of sample. The effect of sample preparation methods namely air-dried and oven dried of the Atterberg limits and compaction characteristics were also studied. The effect of water content was studied on the strength characteristics of compacted specimens of the soil near the surface.

The chemical content of the soil namely oxides of iron and aluminium vary slightly with depth, which is consistent with the change in the colour of the soil in the same range. The ratio of SiO_2 to metal sesquioxides (R_2O_3) increases with depth,

indicating that the proportion of *R^O-s,* to silica oxide is higher near the surface, showing higher degree of weathering at the surface, which decrease s with depth. The ratio of SiO_2 to R_20_3 is found to vary from 1.97 to 2.22, indicating that the soil is not laterite but more likely to be halloysitic. It is lateritic at the surface up to 2m depth and non lateritic from that depth downward. The variation of specific gravity, grainsize distribution, Atterberg limits show a clear reduction of weathering intensity from the surface downward. The soil has more clayey behaviour near the surface while at the bottom part of the borehole it gradually became non-plastic. Drying methods have a strong effect on the Atterberg limits and compaction characteristics, which is characteristics for soil with iron content, leading to a conclusion that these tests should be done on naturally prepared samples without pre drying up to the depths where weathering has developed. The double oedometer test on undisturbed samples reveal that the soil show slight swelling behaviour at low level of pressure but collapsing behaviour at high level of stress.

Thesis Title: **SIMULATION OF TRIAXIAL COMPRESSIONAL BEHAVIOUR OF SAND BASED ON STATE CONCEPT**

Submitted by: **Prabhat Kumar Jha**

Supervisor: **Padma Khadka and Kaushal K. Jha**

ABSTRACT:

An elastic-plastic constitutive model, which account for the combined influence of density and effective stress in a unique way, is developed for the triaxial compressional behaviour of sand under monotonic loading.

The study addresses many important issues relevant to sandy soil behaviour and represents a unite experimental and theoretical effort to develop a constitutive model for sandy soils comprising balanced features of accuracy, simplicity and versatility. Particular attention in both experimental and theoretical considerations is given to the effects of density and effective stress as well as their combined influence on the sandy soil behaviour.

A distinct feature of the constitutive model of the present study is that a single set of values of the material parameter is used to model the behaviour of the given sand. The parameters of this relation are expressed as function of an index parameter established in the framework of the steady state of deformation

concept. The parameter employed in the relation is the State Index, I; which characterizes the sandy soil behaviour by accounting for the combined effects of the density and effective stresses related to a given initial fabric.

The elastic-plastic constitutive model is developed in the framework of the incremental theory of plasticity. The framework is developed by the modification of the torsional simple shear test framework, in stress space definition, yielding criterion, stress-dilatancy relationship, plastic modulus, and loading index. The model is defined in a stress space that enables to account failure surface which incorporates the effects of density and effective stress.

The accuracy and effectiveness of the elastic-plastic constitutive model is assessed through a comparison of the measured and predicted behaviour of the Bagmati sand as well as the Toyoura sand in monotonic triaxial test. The model correctly predicts the stress-strain characteristics observed in the undrained triaxial compression tests on medium dense, loose, very loose sand, providing gradual change in these characteristics from those typical for dense sand, with continuous increase of the shear stress with straining, to those typical for loose sand, with drop in the shear stress associated with development of the large strains including the extreme cases with zero residual strength.

Graduation Year 2006

Thesis Title: **DESIGN OF SUPPORT SYSTEM OF DESANDER BASIN OF KALIGANDAKI 'A' HYDROELECTRIC PROJECT**

Submitted by: **Amal Shrestha**

Supervisor: **Prof. Dr. Akal Bahadur Singh**

ABSTRACT:

The use of formula based on Principals of Elasticity could affect the accuracy of result when applied to severely faulted rock mass. Numerical modeling has proved to be a powerful tool for calculation of stress encountered in underground excavation and other necessary parameters. Though a numerical model can not totally dispense the need of insitu and Laboratory testing-numerical studies and definitely help to overcome the limitation of physical testing.

Construction of underground structures and facilities are expensive. Further more the design excavation also requires to know geologv and topographic features so unfavorable condition could be avoided. Here loo Numerical Analysis could provide necessary tool to predict rock mass behavior under anticipated loading conditions.

Based on existing Held data of experiments and geology of the area, a numerical analysis has been done of the slope model to calculate stress and rock parameters calculated by using Rocklab Program, with these result the necessary support system has been designed using Analytical Method for Rock Support Interaction Analysis.

Thesis Title: **ANALYSIS OF SUPPORT SYSTEM OF UNDERGROUND DESANDING CAVERN OF MIDDLE MARSANDI HYDRO-ELECTRIC PROJECT**

Submitted by: **Hari Prasad Adhikari**

Supervisor: **Prof. Dr. Akal Bahadur Singh**

ABSTRACT:

Analysis and estimation of support requirement of the underground excavation is not an easy task due to so many parameters related to ground. The rock mass condition of the study area was represented by highly fractured Quartzite. For the analysis of support system for the Desander cavern, two empirical systems were used. One of them is Geomechanics classification of rock mass rating (RMR). and the other is Rock Tunneling Quality Index, Q. Empirical methods used in design are based on rock mass classification system, therefore these methods gives too general design solutions. In the present, the convergence confinement method of analysis is carried out for analyzing the support requirement of Desander cavern of middle Marsyangdi hydroelectric project. Numerical computation was carried out to compute the elastic range of deformation of tunnel wall with the help of FEM elastic model. Later the deformation computed by FEM model was checked by Examine-2D model.

Both methods of analysis result in about the same range of deformation but this range of deformation has been found to be exceeded the deformation as obtained by convergence confinement method and underestimate deformation as obtained by field measurement. Support system that is actually applied seems to be conservative compared to the support system that would be required by induced stress- Conversely similar support system can be obtained by assuming that deformation modulus is reduced by excavation / blasting.

Two dimensional stress analysis is carried out with considering the different condition of forces i.e. water pressure and support pressure. These analysis help to know qualitatively, how the stress is distributed within rock mass around the excavation with different combination of forces.

Thesis Title: **EVALUATION OF EFFECT OF VEGETATION ON SOIL SLOPE STABILITY BASED ON THE NUMERICAL SIMULATION OF PROGRESSIVE FAILURE IN SOIL-ROOT MATRIX CONTINUUM**

Submitted by: **Ram Chandra Tiwari**

Supervisor: **Ass. Prof. Padma Bahadur Khadka and Hom Nath Gharti**

ABSTRACT:

With the consideration of increasing trend of bioengineering approach in soil slope, its analytical justification pertinent to the stability factor is essential for the effective design and implementation. Numerical simulation considering the progressive failure and the soil-root matrix interaction certainly provides the reliable way for the analytical evaluation. However, both progressive failure and the soil-root matrix interaction are not easy to treat both analytically and numerically. Hence, new numerical scheme in finite element method is used to simulate the progressive failure in simple and effective manner, and homogenization of the soil-root matrix is implemented for the easy treatment of networked continuum.

Various cases of soil slope with respect to different slope geometries, vegetation types, root depths (maturity periods) and

root area ratios (RAR) are simulated under dry and fully saturated conditions. With dry and fully saturated conditions, behavior of slopes in most favorable and worst conditions can be simulated. Preliminary results show that the new numerical scheme can simulate the progressive failure efficiently- Similarly, some exciting behaviors of soil-root matrix continuum are effectively captured with the consideration of homogenization. Results for various cases with respect to root area ratios (RAR) suggest that certain range of root area ratio (effective RAR range) should he identified for the given slope geometry, vegetation type and maturity period. Effective RAR range represents all the RARs which impart factor of safety greater or equal to bench mark factor of safety, bench mark factor of safety being the anticipated factor of safety depending on various factors (Demographic distribution, proximity to utilities etc.). Beyond the effective RAR range vegetation does not impart to the stability of the slope. Theoretically, higher range of RAR beyond the effective RAR even cause the slope failure resembling the behavior of steel reinforcement, in concrete. Within the effective RAR range, stability factor increases initially and tends to saturate to a constant factor. Fully saturated slopes are naturally vulnerable to the failure, with appropriate RAR and vegetation types and maturity periods, stability factor can be increased significantly as in dry slopes.

The role of vegetation in stability factor of the soil slope, as expected, becomes significant after certain maturity period when roots have pervaded the certain depths, nevertheless resistant to erosion even at the earlier period cannot he neglected.

Nonlinear FEM approach with free mesh method has been implemented in new computational approach. Results are verified with ordinary nonlinear finite element method and limit equilibrium computation comparing the factor of safety and failure surface of the certain slopes. Results obtained with the new computational approach are in close agreement with the results obtained with both ordinary nonlinear finite element method and limit equilibrium computation. Factor of safety field obtained by the limit equilibrium method reveals that the determination of unique failure surface with least factor of safety is more difficult for more unstable slopes. Hence, it is desirable to define the critical region rather than to pinpoint the unique location of critical failure surface.

This physical simulation scheme with new treatment for failure phenomenon can provide reliable information about the stability factor of various soil and soil-bioengineering slopes. Such information can effectively be used to assess the landslide risk and design the structurally safe and economic soil-bioengineering slopes.

Thesis Title: **ANALYSIS OF CONSOLIDATION AND CURTAIN GROUTING OF DAM FOUNDATION USING GROUTING INTENSITY NUMBER (GIN) TECHNIQUE**

Submitted by: **Suchan Lamichhane**

Supervisor: **Prof. Dr. Akal Bahadur Singh**

ABSTRACT:

The grouting method GIN in dam foundation for seepage control is one of the newest technologies now used in Rock Grouting. The Grout Intensity Number (GIN) method was first introduced by Ewert and more elaborated by A. C. Houslby.

The author simply has tried to assess the validity of the GIN method validity which has now been used world wide in the context of different dam construction. Middle Marsyangdi Hydro Electric Project is one of the medium power projects in Nepal. Grouting has been used in dam foundation for seepage control and consolidation of the foundation of the dam. A very extensive program of curtain grouting has also been carried out at the Dam section.

One of the principles of the GIN method is to relate applied pressure to the volume of the grouts/voids/pores. This is

represented by the constancy of pressure multiplied by volume. However the MMHEP project has not used a constant GIN value and has used GIN value ranging to 100 to 1800 bar lit/m. The author recommends a constant GIN value of 1200 bar lit/m and has further restricted the pressure and volume to a defined maximum value of 20 bar and 360 lit/m respectively.

Since the nature of pores/fractures in rockmass cannot be assessed with desired reliability, there is much room for improvement of the GIN method of grouting. This can however achieved from field experiments, observations and analysis.

It is felt that the GIN method represents a clear step in the right direction aimed at optimizing and economizing the grouting process. GIN method seeks to achieve this by replacing the traditional method of grouting till refugal. By using the GIN principle for grouting performance has optimized grouting process to a more scientific and economical process.

Thesis Title: **SETTLEMENT OBSERVATION AND ANALYSIS OF SIX- STOREYED OFFICE BUILDING IN KALIMATI, KATHMANDU**

Submitted by: **Sudarshan Maharjan**

Supervisor: **Dr. Samuel Handali and Prof. Dr. Ram Krishna Poudel**

ABSTRACT:

Observations on the settlement of a multi-storey office building located at Kalimati, Kathmandu has been made to study the settlement characteristics of buildings built on a thick organic soil deposit over a period of time. This is the first research ever done on the settlement of buildings on Kalimati deposit. The building is 6 storeyed with basement floor, resting on a mat foundation cast over 102 bored piles of 40 cm diameter and 4.6 m long. Observation of settlement of the building under construction was made with auto level instrument at regular intervals of time or before and after an addition of load, starting from day 136 after the construction started until day 441. Soil properties of the site were obtained from earlier soil investigation work. Four different methods of settlement prediction techniques were carried out for building, namely finite difference method, Terzaghi's method, OIsen's method and Schiffman and Aboshi's

method. The predictions are then compared with the observation results.

The maximum observed settlement has reached 121 mm up to day 441 since the observation started at day 136. With the help of finite difference analysis it is estimated that 107 mm settlement has occurred since the beginning of the construction. Initially the building lilts towards the North-Western direction. At the end of settlement observation at day 441 the building tilts in the West direction with angular distortion of 0.00197. The maximum differential settlement till date has been 59 mm.

The finite difference prediction shows reasonably well results, showing comparable settlement magnitudes with those shown by some of the columns and matching the pattern of observed settlement record for most of the columns. The other methods of prediction appear to significantly underestimate the rate of settlement of all the columns throughout the observation period. It has been estimated that the consolidation settlement at the final stage of observation at day 441 has reached 42 % of degree of consolidation.

Thesis Title: **SOIL EROSION ESTIMATION OF COMPLEX CATCHMENT USING TRIANGULAR NETWORK MODELING**

Submitted by: **Bajra Man Singh Thapa**

Supervisor: **Ass. Prof. Padma Bahadur Khadka and Hom Nath Gharti**

ABSTRACT:

Soil erosion is a crucial problem in Nepal where more than 80% of (he land area is mountainous. The soil erosion assessment, a persistent and serious research problem, is a capital intensive and time consuming exercise because of topographical complexity and geological heterogeneity of the watershed. An Empirical and physically based approach can he used to predict the soil erosion. An Empirical approaches are commonly used due to heir simplicity in computation and efficient integration with G1S (Geographic Information System). RUSLE model is most popular among empirical approaches, because it is very simple and can be used for simple channels to general watersheds and complex catchments also. L factor in R LISLE is the most sensitive and difficult parameter to compute in complex watershed. In G1S square grid cells are used to compute the localized L factor. However, using the grid cells for the very complex watershed demands heavy computation and the error

minimization in the sharp boundaries is very difficult. Hence, a new technique based on the triangular networks is developed for the efficient and reliable computation of soil erosion based on the RUSLE model. Triangular networks map the complex topography with relatively few numbers of elements, thus reducing the computational cost drastically. In addition, triangle is the basic geometry in two dimensions and every complex linear two dimensional geometrical domain can be discretized into [he triangular networks with known error measures.

C'omputation of localized L factor is the major issue in RUSLE modeling. Direct computation of L factor based on the geometry of the slope is a cumbersome task with triangular networks in complex watershed- because computing the upslope contributing area in complex geometry may be very difficult. Therefore, the continuous runoff method is used for the computation of upslope contributing area of each cell. in this method, runoff from each cell flows continuously depending on the flow direction, effective flow width and slope of the element, until it reaches to the outlet. Upslope contributing runoff is the cumulative runoff it receives during the continuous discharge period. Contributing upslope area is directly obtained from the upslope contributing runoff.

In this thesis, first the soil erosion is computed for various erosion plots in Jhikhu Khola watershed. Result thus obtained are compared with various empirical methods and observed data. Results show that the new technique reliable estimates the soil erosion. Soil erosion from the entire Jhikhu Khola watershed is also computed with new method using approximately estimated parameters. Computed soil erosion pattern depicts the real features of the watershed. Nevertheless, more reliable parameters should be used for the more accurate information of the soil erosion from the watershed.

Due to the simplicity and the reliability, this method can effectively be integrated with GIS. As the runoff is used to compute the L factor, this method can also be applied for the various conditions of runoff with the recently devised USLE-M model.

Graduation Year 2007

Thesis Title: **FIELD AND LABORATORY GEOTECHNICAL INVESTIGATION AT INSTITUTE OF ENGINEERING CAMPUS, PULCHOWK**

Submitted by: **Gopal Acharya**

Supervisor: **Dr. Samuel Handali and Mr. Padma Bahadur Khadka**

ABSTRACT

A comprehensive study on the subsoil conditions of Pulchowk Engineering Campus has been carried out. Three new boreholes up to 11 m depth and 16 Dutch cone tests were carried out in the campus premises. In addition, 33 past boreholes data were collected and included in the compilation of soil data from the campus premises. The results show that Pulchcwk campus premises can roughly be divided into five zones, each zone up to 10 to 12 m depth generally consists of two layers. In Zone I the upper layer was low plastic clay (CL) and below this is found low plastic sill (ML). In Zone II the upper soil is CL layer and the lower is SM layer. Zone III consists of ML layer followed by SM layer. Zone IV upper layer is found to be CL soil and followed by OH soil. Zone V deposits consists of 3 layers,

namely CL, SM and CL layers. The upper CL layer is from 0 to 6m, middle layer SM is from 6 m to 10m and the lower CL layer is from 10 m to 12m depth. The correlation between organic content with soil properties proposed by Upadhyay (2005) based on data of soil with high organic content obtained from Kalimati, Kirtipur and Kopundole (Neupane, 2004) were extrapolated to include data from soils with low organic content found in the Campus premises.

Relationship between strength parameters obtained from Dutch cone test, SPT and UU triaxial test have been developed. The relationships between cone resistance Qc and N value from SPT for CL, ML, SM and OH layers are found to be linear. As the size of the soil panicle decreases from SM, ML, CL and OH respectively, the tangent of the line found to decrease. The relationship between N value and Su from UU triaxial tests obtained by the Author is found to be linear also, consistent with that of Chicago soil as proposed by Schmertmann (1975). As plasticity index decreases, the slope of N vs. Su graphs is also found to decrease. The linear correlation between Qc and Su shows that tangent of the lines for OH, CL, ML soils are found to found to increase as the soil becomes coarser.

The relation between cone resistance and friction ratio developed to identify and classify the soil originally proposed by Robertson and Campanella (1986), Schmertmann (1978) and Brouwer (2002) show that the boundary lines separating the soils proposed by them are not applicable for the soils obtained from Pulchowk Campus premises. A new chart is proposed by the Author which can be used to interpret the soil type at Pulchowk Campus which can further be extended to cover soils from and even Kathmandu valley soil as a whole.

Graduation Year 2008

Thesis Title: **EFFECT OF RICE HUSK ASH LIME MIXTURE ON ENGINEERING PROPERTIES OF SUBGRADE SOIL**

Submitted by: **Binod Kumar Mauwar**

Supervisor: **Dr. Samuel Handali**

ABSTRACT

This research describes a study on the effect of lime and rice husk ash mixture on the engineering characteristics of fine grained soil of inorganic clays of low plasticity. Harvard Miniature compaction characteristics and unconfined compression test was carried out to determine the strength of soil- additive samples subjected to prior immersion and without immersion. Commercially available quick lime and rice Husk ash were used as additives. The amount of lime added to the soil sample as percentage of the dry soil mass was 5% and rice husk ash was in the range of 0 to 20%.

The results of this study show that the addition of the rice husk ash only (without addition of lime), can improve the unconfined compressive strength of the soil through 17 to 30% only, where as the addition of RHA combined with lime can improve the

strength of soil in the range of 200 to 800%. Curing time has no effect on the strength of soil if it was only treated with RHA. However the strength of soil mixed with 5% lime RHA mixtures generally increased with increasing curing time. Twenty eight days, curing was found to be more effective than 2,7,28,60 and 90 days curing period. The reduction in strength due to prior immersion was less when 5% lime was added on the soil-RHA mixtures.

The maximum dry unit weight of the soil was found to decrease while the optimum water content was found to increase with the increased in the rice husk ash content. The PH value of the soil mixture having acidic property increased with increase of RHA.

The value of CBR ratio increased as the percentage of RHA was higher than 10% in soil mixtures. The swelling characteristics decreased as the percentage of RHA increased by 5 to 20%. The results of the study show that RHA alone (without addition of lime) was beneficial in enhancing CBR and swelling characteristics of the soil. The addition of 5% lime on the soil-RHA mixtures enhanced all the desirable characteristics of the sub grade soil for pavement purposes, namely the strength, CBR as well as reducing the swelling and shrinkage potential of the soil.

Thesis Title: **SIMULATION OF SEISMIC LIQUEFACTION PHENOMENON BASED ON HYBRID MODEL OF FINITE ELEMENT METHOD AND CELLULAR AUTOMATA.**

Submitted by: **Govinda Prasad Wagle**

Supervisor: **Associate Prof. Padma Bahadur Khadka**

ABSTRACT

This research has concentration in simulation of liquefaction phenomenon of entire area of study. The program has been formulated based on plan strain consolidation analysis of a Biot elastic-plastic material using 8-node rectangular quadrilaterals for displacements. Pore water pressure have been coupled to 4-node rectangular quadrilaterals at connectivity node. Failure criteria used for the evaluation of liquefaction is Mohr-Coulomb failure criteria. Visco-plastic strain method has been adopted for programming the finite element method. Direct percentage fines content has not been used in the program but it has been incorporated with correlation of cohesion, friction angle, modules of elasticity, permeability of soil etc. Properties of cellular automata rules have been adapted for the simulation of liquefaction phenomenon. Cellular Automata is a suitable technique to simulate such complex behavior by grasping its

simple properties. Graphic presentation for simulated behavior of liquefaction soil has been done in Kitware Para View 3.0.1.

Parametric analysis for single layered soil has been done to study the effects of soil properties in liquefaction. Simulated behavior showed that it advances with step jumping in the time history analysis. Although, the entire process is progressive but a number of cells have liquefied instantaneously at certain interval of time which covered larger area instantly. Moreover, the study showed that liquefaction does not occur in clay or clayey soil with certain intensity of dynamic loading which is sufficient to cause liquefaction in land. Parametric analysis showed that the relation between liquefaction and friction angle is inversely proportional. Same relation has established with cohesion for its very small value. Dilation of sand pertain the plastic volume increase during undrained loading condition. Small dilation can prevent large liquefaction. Dilation increases the strength of soil with increasing friction angle as well as it creates the pore spaces within the soil element where pore pressure can dissipate for instant.

Simulation shows that liquefaction started from the left or right boundary and it goes towards centre of the domain. More likely it advances from the side of application of load. For the same

intensity, negative pore water pressure is more crucial to liquefaction than positive pore pressure. Pore pressure concentrated around weak zone of liquefaction which ultimately can cause sand boiling or piping in soil. In the case of layered soil, overlying layer is more susceptible to liquefaction rather than underneath layer. Liquefaction in underneath sand layers can cause settlement in clay layers at top.

Liquefaction is a disorganized behavior of soil which can be not predicted precisely. For the homogeneous soil domain with same prevailing condition, liquefaction started from left or right boundary and advances towards the centre but it may or may not cover whole domain. Cellular Automata has been found to be reliable computation procedure for such complex phenomenon.

Thesis Title: **EVALUATION OF SOIL LIQUEFACTION POTENTIAL OF AREA WITHIN THE PREMISIS OF INSTITUTE OF ENGINEERING CAMPUS, PULCHOWK USING DUTCH CONE TEST AND STANDARD PENETRATION TEST DATA.**

Submitted by: **Him Jyoti Thapa**

Supervisor: **Dr.Samuel Handlai**

ABSTRACT

This research is an attempt to study the liquefaction of Pulchowk Campus, Lalitpur. Following the procedure of Robertson and Wride (1998), the analysis has been done using the result of 22 Dutch cone tests performed in the campus premises. Similarly SPT data from 36 existing boreholes were used following the procedure of Simplified Method (NCEER, 1997, Youd et al., 2001). The analysis were performed on the five different soil zones in the campus and the liquefaction potentials of each soil layer in the zones was examined for earthquake ,magnitudes of 6.5, 7.5 and 8.5 and maximum horizontal acceleration of 0.5g. All the layers are fine grained soil, ranging from silty sand (SM) to organic clay (OH). In general the silty sand (SM) soil layers zone 111 and zone V were found to liquefy under the given

magnitudes and ground acceleration while the organic (OH) layer present in zone IV does not liquefy. The two other types of fine grained soil layers, namely low plastic clay (CL) and low plastic silt (ML) show mixed results, i.e., in some cases liquefaction was predicted while in other cases no liquefaction was predicted.

As a part of this research, adjustment has been done in the classification charts originally proposed by Robertson and Campanella (1986), Schmertmann (1978) and J.J. Brouwer (2002) to fit the soils of Pulchowk Campus Premises. A new chart is proposed by the author having four zones namely SM, ML, CL and OH separated by a dark line depending on the cone resistance and friction ratio which can be used to interpret the soil type at Pulchowk campus and even of soil from Kathmandu Valley as a whole.

KEY WORDS: Liquefaction, CPT, SPT, Fines

Thesis Title: **NUMERICAL MODELING OF SOIL STRUCTURE INTERACTION UNDER SEISMIC LOADING**

Submitted by: **Niraj Acharya**

Supervisor: **Associate Prof. Padma Khadka**

ABSTRACT

A nonlinear finite element model is developed to simulate soil structure interaction for scrip footing. The soli structure system is idealized as 2D plain strain model. A rigorous compute programming is done in G-Fortran. Direct integration in time domain approach based on theta method is adopted for numerical solution of dynamic equation. Damping is introduced in terms of Rayleigh damping coefficients. Mohr Coulomb failure criterion is used as yield criterion.

The results from the author developed finite element program are compared with results from SAP 2000 V10. The results infer that foundation Stress and deformation reduce in the soil structure interaction system compared to 'no soil structure interaction system" because some stresses are shared by the structure thus facilitating structure to undergo certain amount of deformation which is not otherwise possible in "no soil structure interaction system'. Parametric studies to evaluate the effect of strength

degradation of foundation and the effect structure to structure interaction on response of foundation are made. Parametric studies reveal that degradation of soil strength during seismic excitation amplifies the displacements of footings and the amplification is proportional to thickness of soil with degraded strength. Similarly, displacement magnitudes of footings increase due to the structural interaction and the percentage increase is more for smaller structure than for bigger structure interacting with each other.

Thesis Title: **CRITICAL EVALUATION OF CURRENT PRACTICE IN SOIL INVESTIGATION AND THE DESIGN OF BRIDGE FOUNDATION IN THE DEPARTMENT OF ROAD.**

Submitted by: **Shiva Prasad Nepal**

Supervisor: **Dr. Samual Handali**

ABSTRACT

The absence of a detail guideline for design of bridge foundation prompted this work to be taken up. To find the current practices of design of bridge foundation in the Department of Roads, Fifty Five number of bridge investigation reports were collected. Those reports were from across the cross section of the country. The data collected were from reports of single to multi spanned bridges up to 10 numbers of spans. These reports were submitted to the Department between the year 1995 and 2006.

Among 55 numbers of bridges 25 were designed as the shallow foundation whereas 30 were designed as deep foundation. More than 70% of the bridges have been founded on granular soils. The suitability of method of boring and the stabilization of borehole in different types of soil was not discussed in any of the reports. Out of 53 bridges only 36 (68%) have been investigated

with number of boreholes equal to the number of foundations. Even a multi spanned bridge was designed based on the investigation data of two or three boreholes. Out of 35, only two reports have presented separate result of laboratory tests for undisturbed and remolded samples.

The Standard Penetration Test was the only field and done in investigations of all bridges. It was carried out in 46 (87%) of the investigation works. The interval of 1.5 m for the SPT test can be considered sufficient for the investigation. Out of the 46 cases of SPT. 41(89%) have applied correction of one or more type. It was observed that most of the corrections made were not according to the principles and suggestions made by different researchers. It was also found that the calculation of average SPT values was not according to the theories of distribution of pressure below the foundation.

In most of the reports settlement was not considered as a separate subject for the analysis of allowable bearing capacity. It was found that the allowable bearing capacity was calculated based on SPT values in large number of bridges using only one method. The most suitable value from different methods should be adopted for the design works. In most of the cases the value of allowable bearing capacity considered for the design works was

found to be on the lower side of the values obtained from different methods. The foundation can be considered as safe but the cost of the construction can be high.

Graduation Year 2009

Thesis Title: **DESIGN OF SUPPORT SYSTEM OF LIKHU IV HYDROELECTRICITY HEADRACE TUNNEL**

Submitted by: **Anil Kumar Yadav**

Supervisor: **Prof. Dr.Akal Bahadur Singh, Mr. Prakash Man Shrestha**

ABSTRACT

The topic of the thesis is "Design of Support System of Likhu IV Hydroelectric Headrace Tunnel". The relevant data were obtained from project site As well as from ITECO Consultant Pvt. Ltd. Minbhawan, Kathamandu. The thesis has been carried out in two parts. In first part classify the rock mass and find out its behavior and in second part design of support system. The rock mass classification has been done on the basis of RMR and Q- system. The design of support system is analyzed by two different approaches i.e. by Empirical method and Analytical method. In Empirical method, RMR and Q system are used where as in analytical method Convergence confinement system is used. The total length of the headrace tunnel is about 4128M. The whole length of tunnel has been divided into seven parts with respect to rock cover and Q-values. The stand-up time is 2-5

days for poor rock section and 1.5-2 months for fair-good rock section. Combined support system (i.e. Shotcrete and Rock bolting) is recommended as a support system for poor rock section and in other section of tunnel can withstand without any support even though spot bolting is recommended. For the purpose of smoothness and reduction of friction loss and future maintenance 300 mm concrete lining is recommended throughout the length of tunnel. Generally, the tunnel is passing through Gneiss and Schist rock formation. The tunnel alignment is generally making the angle with North i.e. called trend are 245 and 220 degree. The design has been done on the basis of sacrificial data, so, the design of the support system might be changed during the construction and it should be ascertained by appropriate monitoring.

Thesis Title: **AXIAL PILE CAPACITY EVALUATION AND DESIGN OF BOARD PILE FOUNDATION OF BRIDGES**

Submitted by: **Buddha Raj Joshi**

Supervisor: **Associate Prof. Padma Khadka, Accociate Prof. Amod Adhikari**

ABSTRACT

Foundation is an essential part of a structure because it transmits load from the structure to the soil below. The deep foundation like pile foundation is required when the depth of supporting soil is significant or the structure is placed on soft compressible soil. Deep foundation is also required if construction is subjected to horizontal load or moment. Piles are designed based on the load that is transferred the structure to the piles; thus the type, size and length of piles are determined accordingly, however, load test should be conducted to verify the design capacity. The scouring and settlement effect on foundation may cause damage of bridges and its occupants. For bridges, deep foundation may help to handle this kind of problems. Due to the lack of provision of pile driving mechanism almost of the works has recommended for bored pile foundation design in our country.

For the research work three sites of bridges were chosen. The data collected for Nakhkhu Khola (Bhaisepati- Tikathali road sector) bridge, Godawari (Tikathali-Balkot road sector) bridge and Sundarighat (Kalopul) bridge. The ultimate load capacity of bored piled foundation is calculated with the help of soil parameters using conventional method of pile foundation design. The method for the analysis of bored pile foundation under axial loading are reported. They may be considered satisfactory for engineering purposes, provided they are used paying due attention to the corresponding relations between theories and reality. The pile load test results were collected and evaluated. The data collected indicates that the field load test were not conducted upto the failure load. The failure load is estimated with the help of load-settlement curve of pile load test. Finally, the comparative study of the calculated and estimated ultimate load has been established. The comparative study indicates the nature of curve is quadratic in nature i.e. the *tested ultimate load capacity is the square function of calculated ultimate load capacity.*

Thesis Title: **CORRELATIONS BETWEEN HAND PROBE AND CALIFORNIA BEARING RATION (CBR) VALUES.**

Submitted by: **Prakash Bahadur Adhikari**

Supervisor: **Associate Prof. Padma Khadka, Accociate Prof. Amod Adhikari**

ABSTRACT

California Bearing Ratio (CBR) is the penetration test developed by the California Division Highways, as a method for evaluating the stability of soil subgrade and other flexible pavement materials. The test results have been correlated with flexible pavements thickness requirements for highways and air fields.

The penetrometer evolved from the need of acquiring data on sub-surface soils that were not obtained by any other means. Out of a number and varieties of penetrometer, Hand Probe is such instrument which gives data of subgrade or any compacted surface easily and quickly. It is also portable instrument out of other penetrometers.

The main aim of this thesis is to use Hand Probe effectively on the road subgrade or on any compacted soil in order to find out the penetration resistance and co-relate it with the CBR given by

Dynamic Cone Penetrometer (as per TRL RN 31) at the same location so that the relation can be used to compute CBR by using Hand Probe at any sub grade soil.

As there is already have a relation to find field CBR with the help of penetration resistance given by Dynamic Cone Penetrometer, it seems worthful to find out new relations for computation of field CBR by using Hand Probe. With the consideration of such necessity this thesis is carried out, so that if we have cone resistance value of Hand Probe, anybody can easily find out field CBR for different kind of soil easily and quickly.

Thesis Title: **SENSITIVITY AND THIXOTROPY CHARACTERISTICS OF KALOMATO SOIL IN KATHMANDU VALLEY**

Submitted by: **Ramesh Karki**

Supervisor: **Prof. Dr. Ram Krishna Poudel**

ABSTRACT

The characteristics of soil not only depends on the index property of soil, but also depends on the external stresses, historical events, environment changes and can aging with time. The many natural phenomena and human made causes also can affect both index and engineering properties of soil. An undisturbed soil in earth developed its strength and properties, through many processes extended over long period after its formation. The soil may undergo through many cycles of imbalanced due to various phenomena before the restoration of equilibrium condition again.

An undisturbed soil, which has a natural structure under equilibrium condition, will loss its load carrying strength i.e. shear strength if it is disturbed or remolded. This effect of disturbance may be substantial to that may make the soil to behave like a liquid. The characteristic of loosing strength of a cohesive soil due to remolding is known as the sensitivity. Moisture content and density remaining the same, the sensitivity

is expressed in terms of a ratio of undrained shear strength of undisturbed sample to shear strength of remolded sample. Remolding causes destructions of balanced particle structure. As a result the effective stress of soil and shear strength is reduced. A cohesive soil may be slightly sensitive to quick depending on their index properties, consolidation characteristic, chemical constituent, formation process and various natural and environment parameter.

A remolded soil regains its strength with time. After the removal of external forces or disturbing stress the soil will be in imbalanced condition and try to come to a new equilibrium condition. With time interparticles arrangement, adsorbed water structure and distribution of ion gets adjusted. The effective stress of soil is increased and finally there will be increase in shear strength with time. This phenomenon of regain in soil properties in a remolded specimen is known as the thixotropic characteristics of soil. Thixotropic behavior is a natural response of a soil structure change in ambient conditions. When a soil gets remolded or compacted, a structure is induced which is compatible with the externally applied shearing stresses. When shearing stops, the soil is left with excess internal energy which is dissipated by particles movements and water redistribution. This process is continued until a new equilibrium condition is

established with the surrounding soil environment which was existed already in rest condition.

The soil may require long time i.e. equal to some geological age to regain the foil original strength. Depending upon the strength regain the soil may be foil or partially thixotropic. Thus Study of strength gain of remolded soil with time at unaltered moisture content and density seems to be a need with references to remolded strength and undisturbed strength.

Kalomato is an organic deposit having characteristics low shear strength, high compressibility, low permeability, low bearing capacity, low specific gravity, low density and high atterberg limits. The soil is a major deposit in Kathmandu valley, which is found at different depth in different layer. So due to booming construction in Kathmandu valley, it is necessary to study its sensitivity characteristics in order to safety predict of the structures against disturbance of soil during construction and seismic shock. It is also necessary to study its thixotropic characteristic of soil to analyze the skin friction development around a pile, to successfully design high rise building which is arising in Kathmandu valley in rapid pace. Study of such regain in shear strength due to thixotropic property could have a large application in the design of piled raft foundation.

Thesis Title: **STABILITY ANALYSIS OF POWER TUNNEL OF MIDDLE- MARSYANGDI HYDROELECTRIC PROJECT**

Submitted by: **Sudeep Parajuli**

Supervisor: **Dr. Akal Bahadur Singh**

ABSTRACT

Design of tunnels in rock is still largely empirical, while rock failure in underground mines and tunnel construction continues to claim lives. Stability Analysis and estimation of support requirement of the underground excavation is not an easy task due to so many parameters related to ground. Rock mass classification like Rock Mass Rating, Rock Tunneling Quality Index, Q still finds wide acceptance in Tunnel design. However, the theory of Tunnel design has not been firmly established.

With the advent of Modern techniques and computerization, there were many attempts made to give theoretical basis for tunnel design. One of the approaches is Strain Energy Stored in the Ground. The Strain Energy Stored in the ground before Excavation is redistributed after the excavation of tunnel. If the maximum Storable Strain Energy is greater than that of Strain Energy after Excavation, it represents Stable Tunnel, otherwise Instability occurs.

Based on the strain Energy concept, Stability analysis of Power Tunnel of MIDDLE MARSYANGDI HYDRO ELECTRIC PROJECT is carried out. The geological location of project area is Lesser Himalayas with Metamorphic rocks mainly Quartizitic and Phyllitic.

The result obtained and comparison between analytical and empirical methods after analysis shows that the empirical methods over estimates the requirement of support where as analytical method is more economical than empirical method but distortional strain energy method may be far better economical and logical design aid in tunnel constructions.

Thesis Title: **CONSOLIDATION BEHAVIOR OF ORGANIC CLAY DEPOSIT IN KATHMANDU VALLEY**

Submitted By: **Shailendra Man Tripathi**

Supervisor: **Prof. Dr. Ram Krishna Poudel**

ABSTRACT

Organic clay soil labeled as 'Kalomato' has been identified as one of the major groups of soil found in Kathmandu valley. Despite of this fact, not much research has been focused on the compression and consolidation behavior of organic clay soil on which high rise buildings are being built. This study is mainly focused on the compressibility characteristics of organic clay soil (kalomato soil) based on the time-compression curves derived from consolidation tests, and also focused on developing some empirical relations between the parameters of index properties and consolidation properties of kalomato soil. The samples were collected from borehole drilled at the bank of Bagmati River, near the Bagmati Bridge at Kupondole.

The laboratory testing program included the index properties test, organic content determination, and routine consolidation test. Similarly four samples at different depth are subjected to long term consolidation test for 100 days at constant pressure of 400

KN/m^2 to study the secondary compression behavior of organic clayey soil.

The result shows that the organic clayey soil of Kathmandu valley labeled as kalomato generally falls into "medium organic soil" with high water content apd Atterberg limits. Increase in organic content results decrease in specific gravity and increase in water content, liquid limit, plasticity index, initial void ratio and compression index. High value of compression index up to 1.36 as well as high value of initial void ratio up to 2.59 was observed. The consolidation test showed that all the samples showed over consolidation but the OCR value generally decreases with depth. The empirical' relationship developed suggests that the initial void ratio and plasticity index can be used to predict the compressibility of soil for Kathmandu Valley as they have better correlation coefficient than other parameters of index properties.

The analysis of time - compression data suggests to use the simplified $t^{1/2}$ method (Developed by Feng and Lee) to determine the coefficient of consolidation as it gives intermediate values between Taylor and Cassagrande method. The study indicates that $C\alpha$ and Cc seems to be not much interrelated. The $C\alpha$ increases with the increasing consolidation pressure; whereas the

time of completion of primary consolidation is found to be decreasing with increasing consolidation pressure. The Cv values are generally high when the consolidation pressure is lower than the pre-consolidation pressure. Beyond the pre-consolidation stress, the coefficient of consolidation decreases. The long term consolidation

Thesis Title: **THE EFFECT OF ORGANIC CONTENT IN SOIL MODIFICATION BY USING RICE HUSK ASH AND LIME MIXTURE OF SOME ORGANIC SOILS**

Submitted By: **Shashank Mishra**

Supervisor: **Prof. Dr. Ram Krishna Poudel**

ABSTRACT

This research describes a study on the effect of organic content in soil modification by using rice husk ash and lime mixture of some organic soils. Harvard Miniature compaction characteristics and unconfined compression test was carried out to determine the strength of soil-additive samples subjected to prior immersion and without immersion. Commercially available quick lime and rice Husk ash were used as additives. The amount of lime added to the soil sample as percentage of the dry soil mass was 5% and rice husk ash was 15%, 20% and 25% by weight.

The results of this study shows unconfined compressive strength of treated soil with 5% lime and 15%, 20% 25% RHA, increases and improved strength is maximum at 20% RHA and 5% lime. Further addition of RHA cause no more strength improvement. However the strength of soil mixed with 5%

lime and different amount of RHA mixtures generally increased with increasing curing time. Twenty eight days, curing was found to be more effective then 7and 60 curing period

The unconfined compressive strength of treated soil with 5% lime and 15%, 20% 25% RHA after 24 Hr immersion, increases and improved strength is maximum at 25% RHA and 5% lime. Untreated soil strength is zero after 24Hr immersion.

The maximum dry density of the samples decreases while the optimum moisture content increases with increasing rice husk ash and lime content

Thesis Title: **ANALYSIS OF STRESSES AND DESIGN OF SUPPORT SYSTEM FOR UNDERGROUNG DESANDER BASIN IN LIKHU-IV HYDRO ELECTRIC PROJECT**

Submitted By: **Yubak Dangol**

Supervisor: **Dr. Akal Bahadur Singh**

ABSTRACT

The thesis titled "Analysis of Stresses and Design of Support System for Under Ground Desander Basin for Likhu Hydro Electric Project" is based on the data obtained from the site visit and secondary data provided from the ITECO. Firstly the design of opening for rock pillar is done for different openings (spacing OD, 0.5D. ID, 1.5D & 2D) by the computer program named 'Examine 2D', factor of safety criteria and extraction ratio criteria. From these analysis the results obtained is spacing between the tunnels will be in between 1.5D or 2D, other assumptions are rejected.

Secondly, the support system is designed based on Empirical and Analytical Method. Similarly, the wedge failure is also done by computer program named 'UNWEDGE'. The empirical method includes RMR-System and Q-System. The RMR-system is

limited for the small excavation (for excavation width less than 10m). However, the design for 16 M opening is done based on the limited parameters. The Q-System of analysis is available for both 16 M opening as well as for the 48 M opening. The support system obtained from this analysis is taken consideration by matching with analytical method as well. The analytical method of analysis is done by allowing initial convergence to 2 mm. By computer program named 'UNWEDGE', we tried for different type of support system to stabilize the higher weight of wedge. We choose with the pattern rock bolt, spot rock bolt, with or without shotcrete. Finally, we conclude that the wedge formed is quite large and to reach the demanded factor of safety by providing limited rock bolts shotcrete is also necessary.

From the results of all support analysis, it is concluded that the combine support system is required. The recommended support is shotcrete of 200 mm thick, pattern rock bolting of 5m length having diameter 25mm and at the spacing 1.0 m x 1.0 m in circumferential and longitudinal direction.

Graduation Year 2010

Thesis Title: **ONE DIMENSIONAL COMPRESSIBILITY, SHEAR STRENGTH AND PERMEABILITY CHARACTERISTICS OF BAGMATI SAND AND OTTAWA SAND**

Submitted by: **Anand Gupta**

Supervisor: **Mr. Indra Prasad Acharya, Mr. Padma Khadka**

ABSTRACT

In this study, one-dimensional compression behavior of Bagmati and Ottawa sand is studied with the use of cyclic oedometer test at different relative density. Cyclic Oedometer test done on dry sand is used to calculate the Resilient Modulus (Mr). Constant head permeability test is carried out to develop the relation between void ratio and permeability (k). Direct shear test is carried out on both the sand to study the variation of friction angle with relative density, gradation etc.

Specimens prepared with initial relative densities ranging from loose to dense are subjected to normal loading as well as hysteretic and repeated loading patterns. The magnitude of the

resilient modulus of sand depends on several factors such as initial void ratio, initial confining pressure and grain size composition among others. In this study, it has been foun3 that the effect of initial confining stress and initial void ratio affect the magnitude of resilient modulus significantly. It is investigated that resilient modulus increases with the increase in void ratio for the same initial confining pressure. For the same initial void ratio, the magnitude of resilient modulus also increases with the increase of initial confining pressure. The Shear strength parameter of both the sand is also studied. The angle of shearing resistance increases with increase in relative density. Plot of permeability against permeability function is also incorporated in this study.

Finally Bagmati and Ottawa sand is compared for each of the above mentioned properties.

Thesis Title: **ANALYSIS OF INCREASE IN SHEAR STRENGTH OF SOIL DUE TO APPLICATION OF BIO-ENGINEERING WITH THE SPECIES HAVING DIFFERENT TENSILE STRENGTH OF ROOTS**

Submitted by: **Anant Raj Ghimire**

Supervisor: **Mr. Padma Khadka**

ABSTRACT

Landslide is one of the natural hazards which causes lots of damages. Different methods of slope stabilization are currently in use, and Bioengineering is one of them. The roots of the vegetation increase the shear strength of soil by transmitting the so developed shear stress to tensile strength bearing capacity of root in the sheared zone. The additional strength created by roots is defined as the growing cohesion, which increases with the vertical stress and the area occupied by the roots. This study includes, increase in the shear strength of soil due to the roots of Bioengineering species and calculation of increase in shear strength by analytical and laboratory test, the direct shear test .This study is undertaken to evaluate the increment pattern of root strength and root numbers. For chosen grass and shrub species, Amliso and Asuro respectively, laboratory tests were

conducted and the results were interpreted in terms of the following findings.

- Measurement of tensile strength of root of different Bioengineering species.
- Increase in shear strength due to the root reinforcement.
- Comparison of increase in shear strength by analytical method and direct shear test.
- Mathematical determination of increase in slope stability by the application of Bioengineering.

Roots are composed differently and different plant species have different structures. So it is difficult to find accurate experimental study on the mechanical performance of the root tensile strength and increase in shear strength of soil due to root reinforcement.

The study was done on the Krishna Bhir which is located along the Prithvi Highway. The area is 82.5 Km west of Kathmandu and can be reached within two hours drive. Monsoon rains badly damaged the Krishna Bhir section in the month of September in the year 2000. Increase in the slope stability of that region due to the application of Bioengineering is analyzed in this thesis.

Thesis Title: **GEOMECHANICAL PROPERTIES OF BAGMATI SAND STABILIZED BY LIME AND DOLALGHAT RED CLAY**

Submitted by: **Arjun Kumar Adhikari**

Supervisor: **Prof. Dr. Ram Krishna Poudel**

ABSTRACT

Clayey Sands that have low plasticity, low compressibility and high strength under loads, are suitable as a base material for any engineering construction projects as well as for roads and building construction. Decrease of plasticity and compressibility as well as increase in strength of these materials can be obtained by many different methods. Of these methods, lime stabilization is a common, applicable, and easy-to-use approach that can improve geo-mechanical and geo-technical properties of clayey sand fills.

This research describes a study on the effect of lime and red residual soil on the engineering properties of Bagmati sand. In this study, some geo-mechanical properties like compressive strength, deformation behavior and ductility of clayey sands stabilized by lime are investigated. Different ranges of gradations were selected for testing and samples were prepared in the laboratory. The red soil which was used as stabilized material,

mixed with sand by 7%, 15%, 22%, 30%, 36% and 40% by weight. Then the mixes were stabilized with hydrated lime at 3%, 6%, 9%, 12% and 15% and cured for 1, 7, 28 and 60 days. Standard proctor tests were carried out to determine the compaction characteristics of the mixes and unconfined compression tests were carried out to determine the strength of samples. The stress-strain behavior of lime-stabilized mixes was plotted and a parabolic function was used to estimate the trend of the stress-strain behavior.

Results of the unconfined compression test show that an increase in clay content up 30%, in the sand-soil-lime mixes, tends to increase the strength of the materials and then decreases. Similarly, strength of the materials is increased with increased in lime content and it becomes maximum at 9-10%. Further addition of lime causes no more strength improvement. Generally the strength of material increased with increasing curing time. The rate of strength gain is rapid in the initial curing days and thereafter very less increase in rate can be noticed.

Thesis Title: **ANALYSIS OF STRESSES AROUND AN UNDERGROUND EXCAVATION IN ROCKS USING FEM**

Submitted by: **Arjun Kumar Pandit**

Supervisor: **Mr. Padma Khadka**

ABSTRACT

The stability of deep excavations depends upon the response of the rock mass to the stress field induced around the excavation. Therefore, an essential part of the design of *engineering structures in/on the rock is the prediction of responses* of rock/rock *masses, often in terms of stresses and the* displacements. Analytical methods which produce close form solutions are used as first attempt for this purpose. These methods, however, are based on simplifying assumptions with respect to geometry**,** *material behavior and the boundary conditions*. So**,** *analytical solutions can* be rarely *of practical concern to rock mechanics problems. As rock consists of* complex *formations and exit a wide* range of behaviours, the analytical methods provide only *approximate solutions.* Hence, a conceptual tool, using numerical methods called Finite Element Method (FEM) has been generated and used for realistic prediction of the behaviour of the complex underground excavations in rockmass at various in-situ stress conditions.

Thesis Title: **ANALYSIS AND PERFORMANCE EVALUATION OF BORED PILE FOR DEEP EXCAVATION SUPPORT SYSTEM AT KATHMANDU VALLEY**

Submitted by: **Kishor Paudel**

Supervisor: **Mr. Amod Kumar Adhikari**

ABSTRACT

Efforts are underway in the greater Kathmandu to raise the elevation of buildings and infrastructures, to combat the problem of urbanization. The major problem associated with these high-rise structures is excavation of foundation. During the excavation of large pits, lateral earth pressure and hydrostatic pressure increase significantly due to movement of soil mass and support installed during this process. It is assumed that the walls, sheet pile, and cut-off wall would resist these forces. In most of the cases in Kathmandu valley such type of walls and structure cannot stand for long time and failure cause in excavated area. This paper presents the results and analysis of a field study conducted to determine the probable case of failure of support pile in District court of Kathmandu, at Babarmahal, Kathmandu as well as support system at Bir Hospital, Kathmandu.

There has been a relatively long history of interest in comparing the various methods of slope stability analyses in geotechnical engineering. In the past two-three years, mainly because of the damages to the structure nearby deep excavation in the Kathmandu valley and vicinity, the interest in comparing particular types of sheet pile with others walls and support system has intensified. Due to lack of technique and experience in Kathmandu soil many designers, design retaining walls for deep excavation more absurdly.

During this study, soil parameter presented in soil Investigation report, actual parameter encountered during fieldwork was compared, and analyses the global stability of the retaining system used, check the stability of pile against horizontal movement and angular distortion.

Finally, this study concluded with a failure of pile due to the very weak soil condition due to significant changes in soil properties during construction, so lateral movement of pile happen causing significant effect on vicinity of the excavated area. For design of such kind of retaining structure, subsurface consisting of soft soil deposits challenges the current understanding of the pressures developed on sheet piles and the parameters used for its design.

Thesis Title: **PROBABILISTIC LANDSLIDE HAZARD ASSESSMENT ALONG THE ROADSIDE SLOPES OF TIMISLEN-RAMAROSHAN ROAD CORRIDOR, ACHHAM**

Submitted by: **Bhim Kumar Dahal**

Supervisor: **Mr. Padma Khadka**

ABSTRACT

Landslide hazard mapping is a fundamental tool for disaster management activities in fragile mountainous terrains. The main purpose of this study is to evaluate the predictive power of weights-of-evidence modelling in landslide hazard assessment in the Lesser Himalaya of Nepal. The modelling was performed within a geographical information system (GIS), to derive a landslide hazard map of the North-East marginal hills of the Achham district.

Thematic maps representing various factors (e.g., slope, aspect, curvature, relief, flow accumulation, distance to drainage, soil depth, soil type, landuse, geology, distance to road, sediment transport index, wetness index and mean annual rainfall) that are related to landslide activity were generated, using field data and GIS techniques. Landslide events of the old landslides were used

to assess the Bayesian probability of landslides in each cell unit with respect to the causative factors.

To assess the accuracy of the resulting landslide hazard map, it was correlated with a map of landslides triggered by the 2009 extreme rainfall events. The accuracy of the map was evaluated by various techniques, including the area under the curve, success rate and prediction rate. The resulting landslide hazard value calculated from the old landslide data showed a prediction accuracy of greater than 78.24%. The analysis suggests that geomorphological and human-related factors play significant roles in determining the probability value, while geological factors play only minor roles. Finally, after the rectification of the landslide hazard values of the new landslides using those of the old landslides, a landslide hazard map is prepared.

Comparative study of hazard mapping method is carried out with heuristic approach. Presences of relative value of landslide hazard map in both methods are almost similar, so the weight-of-evidence modelling appears to have extensive applicability to the mountainous terrain of Nepal.

Thesis Title: **SLOPE STABILITY ASSESSMENT OF KRISHNABHIR SLIDE USING BACK ANALYSIS TECHNIQUE**

Submitted by: **Trilok Nath Ghimire**

Supervisor: **Mr. Padma Khadka**

ABSTRACT

This thesis work has presented the slope stability assessment of Krishnabhir Slide using Back Analysis technique. Back Analysis is found to be very effective technique for assessing slope stability condition. The trend of the slope vulnerability can easily be predicted with this technique in nearby slopes of almost similar material properties.

The back analysis was done for the Krishnabhir slide slope with the availability of prefailure slope geometry and soil profile data along with groundwater table location. The back analysis was carried out with Slide 5.0 Software by adopting the cohesion intercept value of soil layers to be zero and assuming weathered rock as soil strata with equivalent friction angles whose value was estimated from Roc Lab Software, produced from Rocscience. The Bishop's Simplified Method was adopted among different LEMs to carry out the analysis. The analysis resulted in the insitu soil strength parameters which were then used in

nearby slope to predict the stability condition. Since the groundwater table of nearby slope was not known, a sensitivity analysis of ground water table with FoS was carried out and the most suitable one matching with the site condition was adopted to predict its stability condition.

In this research, it has been found that Krishnabhir slope is susceptible to undergo long slope slide rather than upper or lower small slides but practically unfeasible result was obtained for long slope which might be due to source of input data for back analysis being doubtful or due to inherent difficulty in exact modeling of long slopes. If material investigation and Ground Water Table monitoring can be done in nearby slopes, Stability Analysis can be done precisely for the design of mitigative measures.

Thesis Title: **OPTIMIZATION OF SUNKHANI - LAPILANG ROAD ALIGNMENT THROUGH LANDSLIDE HAZARD ASSESSMENT**

Submitted by: **Chitra Bahadur Thapa**

Supervisor: **Mr. Padma Khadka**

ABSTRACT

Route alignment optimization model is an efficient tools for the planning and feasibility study of linear engineering structures. Selection of road alignment needs numbers of variables to be dealt with so that to achieve fundamental principle short, safe, easy and economical alignment. The main purpose of the study is to optimize the road alignment in Lesser Himayala of Dolakha District with respect to safety governing factors and cost governing factors. Various types of natural disaster including landslide, slope failure, flood, and earthquake are common in the Himalayan regions because of rugged topography and fragile geology. Among them the landslide is the prominent factor that results road unsafe and costlier. Construction of roads in the area disturbs naturally formed slopes, resulting in instability on the slope.

A landslide susceptibility map is prepared based on landslide-controlling factors including slope, aspect, relief, land use, soil type, lithology, soil depth, distance to drainage, distance to fault, distance to fold, distance to thrust, geological formation, rainfall for safety consideration. Presence of landslide is used to analyze Bayesien probability of landslides as weight of evidence modeling by Geographical Information System (GIS) software. The success rate of the model is 88.3% which shows that the weight of evidence modeling is applicable. Cost weighted map of construction cost, land use cost, slope stabilization cost, operation cost and maintenance cost are prepared for cost consideration.

From the cost weighted map, landslide susceptibility map, and obligatory points, different route corridors are selected and fixed the road alignments. These road alignments are crossed with the cost weighted map and the cost of the each road alignment is derived. Detailed survey design and estimate has been done for one alignment and when compared the cost with that alignment only 5% deviation in cost is found. The result shows that shortest route will not be always economical. Road alignment determination associates various variables, therefore analysis that deals those variables simultaneously is essential.

Thesis Title: **CORRELATION BETWEEN RESILIENT MODULUS AND CBR VALUE OF TRISHULI RIVER SAND**

Submitted by: **Ram Kumar Shrestha**

Supervisor: **Prof. Dr. Ram Krishna Poudel, Mr. Indra Prasad Acharya**

ABSTRACT

The objective of this research is to develop empirical correlations between Resilient Modulus (MR) and California bearing Ratio (CBR) rating of cohesionless soil. For this purpose, laboratory test was conducted on Trishuli River Sand. The various literatures have shown that the resilient modulus test was conducted on clayey soil. Very limited information on resilient modulus of sandy soil has seen in the literature. Therefore, in this research an attempt has been made to find the resilient modulus and CBR rating of the sand at different relative densities and also attempted to correlate the findings of a laboratory measurement of resilient modulus and its CBR rating of the sand.

The resilient modulus of the soils was determined from the cyclic Odeometer test. The repeated load test was done on dry sand at different relative densities. Direct shear testis also carried out of the sand to study the variation of shearing angle with relative

density. In the study of the shear strength parameter of the sand, the angle of shearing resistance increases with increase in relative density. Similarly, the resilient modulus and CBR value also increases with the increase of relative densities.

Specimens are prepared at the relative densities ranging from loose to dense state. The compactness is subjected to normal loading as well as hysteretic and repeated loading patterns. The magnitude of the resilient modulus of sand depends on several factors such as void ratio, confining pressure, grain size composition and others. In this study, it has been found that the confining stress and void ratio affect the magnitude of resilient modulus significantly. It is investigated that resilient modulus increases with the decrease in void ratio for the same confining pressure. For the same void ratio, the magnitude of resilient modulus also increases with the increase of confining pressure.

The focus of the present study was to find the resilient modulus of the sand and to develop a mathematical correlation between resilient modulus & California bearing ratio of the sand.

Graduation Year 2011

Thesis Title: **SHEAR STRENGTH AND DEFORMATION CHARACTERISTICS OF CLAYEY SOIL AT DIFFERENT CONSISTENCY**

Submitted by: **Bikash Devkota**

Supervisor: **Prof. Dr. Ram Krishna Poudel, Mr. Padma Kaddka**

ABSTRACT

Clayey soils commonly occur as soft, unconsolidated surgical deposits. They may also occur as strata beneath other surgical deposits. These soils are problematic as they are very highly compressible and are of very low shear strength. In valley like Kathmandu, clayey soils are found in abundance. Utilization of this marginal ground is required in increasing number of instances in the recent years. Hence suitable geotechnical design parameters and construction techniques needed to be found for this type of ground condition. The characteristics of soil is depends on the index property of soil, the external stresses, historical events, environment changes and can aging with time. The many natural phenomena and human made causes also can affect both index and engineering properties of soil. An

undisturbed soil in earth developed its strength and properties, through many processes extended over long period after its formation. A disturbed soil can be utilized effectively by different modifications by artificial methods.

A study was done mainly to establish the Geotechnical properties of clayey soil collected from the bank of Bagmati River near newly constructed bridge at Kopundole at Kathmandu valley. The data's are obtained from laboratory tests. Correlations and geotechnical parameters are established to assist in the preliminary design process.

From the correlation derived, it shows that unconfined compression strength decreases with the increase in moisture content nonlinearly. Also, the decrease in the value of friction angle and cohesion with increased water content linearly is found from correlations. From the correlation derived on compressibility parameters, it shows that the compression index increases as water content increases. The coefficient of volume change, m_y also increases as water content increases but it shows the values decreased with pressure for particular water content. The coefficient of consolidation, c_v also increases as water content increases but c_v values are generally high when the

consolidation pressure is lower than preconsolidation pressure, beyond preconsolidation pressure c_v decreases.

Thesis Title: **COMPRESSIBILITY AND SHEAR BEHAVIOR OF LIME MIXED CLAY SOIL**

Submitted by: **Bindu Khanal**

Supervisor: **Prof. Dr. Ram Krishna Poudel**

ABSTRACT

This research describes a study on the effect of lime as additive on the engineering characteristics of fine grained soil of Babarmahal, Kathmandu. Standard Proctor Test was conducted to obtain the optimum moisture content and maximum dry density. For unconfined compressive strength soil sample was prepared using Harvard Miniature apparatus. For Compressibility one dimensional consolidation was carried out. Commercially available lime (quick lime) was used.

The results of the study show that the addition of the lime, can improve the engineering properties of the soil. The soil maximum dry density is found to be increased compared to natural sample. The addition of 3 % of lime has been found to increase the maximum dry density by 0.6 %. Similarly the addition of 6 % of lime has been found to increase the maximum dry density by 4.82 %, where as further increasing the lime content to 9 %, 12 % and 15 % the values of dry density has been

increased by 5.5 %, 6.2 % and 7.5 % respectively. With increasing content of lime, the optimum moisture content is consistently decreasing.

For natural soil sample the unconfined compressive strength was 1.018 kg/cm . For 6 % of the lime mixed soil the value of the strength was 1.022 kg/cm"".Similarly for 9 % of the mixture the strength was further increased to 1.193 kg/cm and was found maximum at 12 % of the mixture which was 1.671 kg/cm .Beyond 12 % the strength was decreased gaining a strength of 1.45kg/cm^2 at 15 % lime mixture.

The consolidation test carried out in different soil sample with different lime proportion shows that the minimum value of coefficient of volume compressibility at 12 % of lime mixing.

Thesis Title: **MECHANICAL PROPERTIES OF CRUSHER RUN BASE MATERIAL**

Submitted by: **Dipendra Uprety**

Supervisor: **Prof. Dr. Akal Bd. Singh, Mr. Padma Khadka**

ABSTRACT

The primary objective of this research is to determine the properties of Crusher run material (CRM) which is extensively used as a base layer in Otta Seal surfacing (low cost Pavement) and River shingle/River bed material (RBM) generally used as sub base material for both controlled (i.e. well graded material) and random (i.e the material collected from the stock pile directly) sample for one particular source i.e. Likhu Khola of Nuwakot District. The materials collected for this research work was from Likhu Khola in Nuwakot district which is situated about a distance of 25.5 Km north-west from Kathmandu valley, where the same material were used for ongoing road project of REP C for Tokha - Guijebhanjyang - Chhahare Road that links Kathmandu and Nuwakot district with shortest distance.

As there isn't any defined proportion of crushed and uncrushed material which can form Crusher run base material the research was also conducted under both controlled and random sample to

determine the proportion of CRM & RBM mixed such that it can be used as Crusher run base material for Otta seal surfacing as well as base material for other types of bituminous surfacing. The samples taken for RBM were also used as the source for forming CRM.

The laboratory tests were conducted for finding the best proportion between CRM and RBM (Source Material) such that CRM & RBM were mixed at different proportion (i.e. 60% CRM + 40% RBM, 70% CRM+30% RBM, 80% CRM+20% RBM) for both controlled as well as random sampling. In addition, tests were conducted for CRM & RBM material individually for both controlled and random sampling. Various tests were conducted i.e. Sieve analysis, ACV, AIV, LAA, FI, EI, Compaction, LL, PL, and CBR.

Among the tests mentioned above, focus was made on CBR value as the Crusher run material for Otta seal surfacing for which CBR should be > 60 %. Thus under controlled sampling it was found that the CBR value for CRM & RBM material mixed at different proportion as mentioned above as well as for CRM material individually was found greater than 90%. The RBM material under controlled sampling individually has its CBR value greater than *60%* and less than 90%.

Similarly under random sampling, the value of CBR for sample with different mixing proportion (i.e. 60% CRM + 40% RBM, 70% CRM+30% RBM, 80% CRM+20% RBM) is found to increase as the proportion of CRM material is increased, whereas the CBR value of CRM material individually (i.e. CRM=100%) is greater than 90 % and the CBR value for RBM individually (i.e. RBM=100%) is less than 60 %. Further from the tests conducted it was found that RBM material has higher resistance to impact and crushing than CRM material.

Thesis Title: **BEHAVIOUR OF COMPRESSED CEMENT STABILISED SOIL BLOCK AS AN ALTERNATIVE WALL MAKING MATERIAL**

Submitted by: **Deepak Raj Bhatt**

Supervisor: **Prof. Dr. Ram Krishna Poudel, Mr. Santosh Kumar Yadav**

ABSTRACT

This research is intended to provide detailed technical and economic information on the production of compressed cement stabilized earth blocks. These include information on suitable soil types, local stabilizers, stabilization techniques, production of compressed stabilized earth blocks and their economical value and potential. Critical review of related "literatures show that soil types, proportions between soil and stabilizer and compaction pressure applied to the moist soil mix affects the quality of the compressed earth block.

The effects of compaction pressure on the quality of the soil blocks, the optimum cement content for stabilization and cost comparison with hollow concrete blocks are prepared. The performance characteristics of local stabilizers are evaluated and comparisons can beamed. The investigation has revealed that

from the blocks produced at the varying cement contents from 4% in increments of 3% up to 13% at constant compressive pressure, all the blocks except blocks produced by 4% cement have 28th day wet compressive strength values well above most of the recommended minimum values for use in structural work. Further increasing cement content results in an increase in the compressive strength value and a decrease in the absorption capacity of the soil block. Increment of the compaction pressure also improves the compressive strength of soil cement block.

The cost comparison with the conventional walling making material, hollow concrete blocks, has revealed that compressed cement stabilized soil block is preferred because it is more economical walling material in itself and permits the use of economical building techniques.

Thesis Title: **RELATIONSHIP BETWEEN MODULUS OF RESILENCE AND SHEAR STRENGTH OF BAIRENT QUARRY SAND**

Submitted by: **Kamal Prasad Chapagai**

Supervisor: **Prof. Dr. Ram Krishna Poudel, Mr. Santosh Kumar Yadav**

ABSTRACT

The objective of this research is to establish the relation between modulus of resilience and shear strength of quarry sand. The source of sand is located in Bairiki V. D. C. 9, Dhading district, the index property and compressibility of sand determined in the laboratory experiment. The resilience modulus is determined by the using cycling loading in Oedometer test. Dry sand is used for the experiment after passing 4.75mm sieve opening, the loading system is complying the AASHTO T 307 procedure. Direct shear test of sample carried by the direct shear test apparatus to determine the angle of sharing of resistance. The modulus of resilience and direct shear test is carried out with varying relative densities of sand.

Experiment for the sand is prepared for the different relative densities and testing starts with lower relative densities dense

state of compactness are subjected to normal loading as-well as hysteretic and repeated loading patterns. Expected magnitude of modulus of resilience is affected by the void ratio initial pressure grain size of the partial. Modulus of resilience is increased with increased initial confine pressure.

Finally, expected out come from the experiment was compared with the previous results of research. Correlation was established modulus of resilience, Relative density and Number of cycles, curves is plotted between shear strength parameter and modulus of resilience with different relative density.

Thesis Title: **INTERACTION ANALYSIS BETWEEN PILED RAFT FOUNDATION**

Submitted by: **Rajesh Kumar Sharma**

Supervisor: **Mr. Padma Khadka, Prof. Dr. Akal Bd. Singh**

ABSTRACT

The development of the country is going on very rapidly. In such a scenario, the high- rise buildings are being constructed as well. In recent years there have been an increasing number of structures using piles raft as a foundation to reduce the overall and differential settlement. For cases where a piles raft is subjected to a non uniform loading, the use of piles with different sizes can improve the performance of the foundation.

Such a large load coming from superstructure is becoming a very difficult to transmit ^{s} in soil beneath. In such a circumstances, the combination of pile and raft is becoming a very useful foundation type for construction of such a buildings and this combination is very useful for the low bearing capacity and excessive settlement. Piled-raft foundations for high-rise buildings have been proved to be an appropriate alternative instead of conventional pile or mat foundations. Piled raft foundation system is able to support the applied loading with an appropriate

factor of safety and reduce the settlement of foundation. In some cases the piles are arranged uniformly and in other cases they are planned strategically to achieve uniform settlement. The behaviour of Piled raft foundation has been investigated by many researches and the influence of some factor like pile diameter, pile spacing, pile arrangement, length of pile, thickness of pile cap have been studied under vertical or horizontal static and dynamic loading.

In this study, the 3-D model for piled Raft foundation is prepared in Computer Software SAP 2000 VI4. Soil properties and Load is appropriately assumed for the analysis.

Using pile raft with different pile diameters in all types of soils, with unequal applied loads, has better operation than piled raft system with similar piles. But its behaviour is not the same in all soils. Results show that the piled raft foundation with different pile diameters may be a good solution to reduce total and differential settlements if the bottom layer is a dense soil. If the bottom layer be a soft soil, using piled raft foundation with different pile diameters can't be a good way to control maximum and differential settlement of raft system and structure. In this case, using other ways such as piled raft system with different lengths piles may be a good attitude to control the maximum and differential settlements.

Thesis Title: **EFFECT OF VARIATION OF CEMENT AND LIME CONTENT ON STRENGTH CHARACTERISTICS OF RED SOIL**

Submitted by: **Rajesh Kumar Yadav**

Supervisor: **Prof. Dr. Ram Krishna Poudel, Mr. Padma Kaddka**

ABSTRACT

Red soil deposits have been found in many hilly areas of Nepal. These red residual soils are locally called as "Rato Mato". There are many studies have been done using red soil as additive but there is lack of study using additive in red soil to see the strength properties.

This research is mainly focused on the effect of addition of cement and lime at various proportions and various times in red soil on its strength characteristics. It shows that maximum dry density increases whereas optimum water content decreases as cement or lime content increases. The increase in unconfinedd compressive strength of un-treated soil is high, whereas the increase is relatively low after that for dry condition.

Addition "of cement led to significant increase in unconfined compressive strength. As percentage of cement increases, there is

decrease in the reduction of unconfined compressive strength of cement treated immersed samples with respect to cement treated dry samples. The unconfined compressive strength of 2.5% cement treated soil tested immediately after preparing the sample is 255 kPa whereas, for 10 % cement treated soil, it is found to be 3533 kPa at 28 days for cement treated dry sample. Also, the rate of increase of unconfined compressive strength is more after 7.5% of cement content in case of immersed samples.

The rate of increase in unconfined compressive strength is less as lime content increases for first, 7 and 14 days. But for 28 days, the rate of increase is relatively high after 5.0 % lime content. Lime (quick lime) treated soil samples get disintegrated when immersed in water. The unconfined compressive strength (kPa) increases relatively less in case of lime treated soil, whereas it is high for cement treated soil. Also, as the time increases, the increase in unconfined compressive strength for cement treated soil is relatively high compared to lime treated soil. There is maximum decrease at 7.5% in the unconfined compressive strength of lime treated dry samples with respect to cement treated dry samples.

Thesis Title: **EFFECT OF STONE DUST ON ENGINEERING PROPERTIES OF CLAYEY SOIL**

Submitted by: **Madhu Sudan KC**

Supervisor: **Prof. Dr. Ram Krishna Poudel, Mr. Padma Kaddka**

ABSTRACT

This research describes a study on the effect of addition of stone dust in the clayey soil in different percentage by weight. Proctor compaction test was carried out and the optimum moisture content and maximum dry density was obtained later, Harvard miniature compaction test was carried out to obtain the required optimum moisture content and maximum dry density and the sample was tested in unconfined compression test apparatus to determine the strength of mixture of soil and stone dust. The amount of stone dust added to the dry soil sample were 3%,6%,9%, 10% ,11% and 20% by weight of soil.

Clayey soils are more problematic for construction and are predominantly available in majority places in Nepal. These soils pose lot of problems to the structures founded on them. Stone dust is a waste by product from Crushers. Some of the product stone dust is being used for construction purposes like brick

making cement manufacture and in road construction these stone dust can be used in stablization due to the presence of lime (Cao) in different percentage, so this admixture could substitute lime as a soil modifier. As the percentage of lime content is increased in the stone dust the effectiveness of admixture is increased ultimately resulting the higher unconfined compressive strength and that signifies that higher the unconfined compressive strength better the result of stablization. As the percentage of stone dust is increased, maximum dry density of the sample is decreased which is accompanied by the increase in optimum moisture content and on further addition of stone dust a stage reaches then there is a reverse effect on maximum dry density and optimum moisture content The unconfined compressive strength of treated soil was tested after curing for 7, 14, 21 and 28 days The result shows that the unconfined compressive strength is increases with the increase in stone dust content and curing days. The increase in strength is not appreciable but the flow characteristics and plastic characteristics of the soil sample gradually decreased with increase in the percentage of stone dust. This reduced plasticity of clay is very much required to avoid the failure of clayey soil. Finally, *waste* stone dust can be used as stabilizers for clayey soil but the effectiveness of stabilizers depends on their lime content.

Thesis Title: **CORRELATIVE STUDY OF COMPRESSIVE STRENGTH AND CALIFORNIA BEARING RATIO FOR SAND STABILIZED BY LIME AND RED SOIL**

Submitted by: **Krishna Dip Shakya**

Supervisor: **Mr. Padma Kaddka**

ABSTRACT

The study portrayed in this thesis aims to derive empirical means of predicting CBR values from the UCS parameters.

The project involved intensive laboratory testing for a range of combinations of Bagmati sand, red soil from Panchkhal near Kathmandu Valley and market available , Lime. The database obtained is those for Clayey Sands. Clayey Sands have low plasticity, low compressibility and high strength under loads, which are suitable as a base material for various engineering construction projects.

Study incorporates investigations on Unconfined Compressive Strength (UCS); deformation behavior, California Bearing Ratio (CBR) Test of clayey sands stabilized by lime. Red soil was mixed with sand by 7%, 15%, 22%, 30%, 35% and 40% by

weight as a stabilizing material. Then the mixes were stabilized with hydrated lime at 3%, 6%, 9%, 12% and 15%. This followed curing for 24 hours, 7 days and 28 days as applicable. Standard Proctor Tests were carried out to determine the compaction characteristics of the mixes, UCS and CBR Tests were carried out to determine the strength of samples. The stress-strain behavior of lime-stabilized mixes was plotted and the correlation between the UCS and CBR developed.

Results of the UCS test reveal that an increase in the clay content up to 35%, in the sand-soil-lime mixes tends to increase the strength of the materials and then decreases gradually. Similarly, strength of the material increases with increase in lime content and maximum strength is attained at about 9-10%. Addition of lime beyond this range causes no more strength improvement. Further, results of the CBR test with clay content 7% to 40% reveals that the maximum strength is achieved at 35%. Therefore for clay content upto 35%, UCS and CBR converges to the same conclusion. The study reveals that the strength derived from CBR test varies by 8.5 to 10 times that of UCS test which is in close agreement with the findings in the paper, *Strength, Modulus and CBR Values for Artificially Cemented Sand* by Omer F. Usluogullari, and C. Vipulanandan, and *Geomechanical Properties of Lime Stabilized Clayey Sands* by M. Arabani and

M. Veis Karami published in The Arabian Journal for Science and Engineering, Volume 32, Number IB.

Thesis Title: **SLOPE STABILITY ANALYSIS USING GEO STUDIO 2004 (A CASE STUDY OF HANGDEWA LANDSLIDE**

Submitted by: **Chet Raj Joshi**

Supervisor: **Dr. Dinesh Pathak, Mr. Padma Kaddka**

ABSTRACT

The Hangdewa landslide is one of the large and historical landslide of Nepal situated in Taplejug district has been active more than 75 years. There are several large and small landslides within the slide zone.The Hangdewa landslide is reactivated annually during monsoon period. Due to high precipitation pore water pressure is increased and landslide is reactivated. From the period of 1932 to 2010, the landslide was reactivated at different time period (1943, 1957, 1963, 1968, 1980, 1989, 1999, 2002, 2003 and 2009). At that period the monsoon rainfall was relatively higher than other years. Thus, this study deals with the probability of slope failure during extreme rainfall of 2009 from April-15 to September-15 by considering a transient modeling and slope model in Geo Studio-2004.

The rocks exposed in and around the study area belong to the Lesser Himalayan Sequence belongs to the Taplejung Window, formed by the erosion of the overlying amphibolite to granulite

facies metamorphic rocks of the Higher Himalayan Crystalline thrust sheet. The intensity of the deformation and grade of metamorphism gradually decreases downward from the MCT displaying the typical inverted metamorphism.

The landslide has taken place at the locations where the thickness of the soil is more than 3 m. The thick soil condition is favorable for the development of pore pressure during the rainy season causing the movement of the material down slope.

The slope is potentially instable having probability of failure 100% when rainfall intensity exceeds the 1250mm during period of 5 months. The transient Geo SEEP model shows that hydraulic conductivity of soil materials is high such that the precipitated water almost infiltrates and the most of infiltrate water is percolate below the fractured zone. Infiltration of most of rainfall water increase the seepage pressure in fractured schist zone and reduce the shear strength lead to failure of slope through the fractured zone. The mean factory of safety of the area is 0.74(<1).

Thesis Title: **LOCAL SITE CHARACTERIZATION OF SINGH DURBAR AREA USING MICROTREMOR MEASUREMENT**

Submitted by: **Dhruba Kumar Wagle**

Supervisor: **Dr. Jishnu Subedi, Mr. Padma Kaddka**

ABSTRACT

The objectives of the thesis are to evaluate the applicability of Microtremor measurements to estimate the local site effects in ground-shaking and to estimate dominant time period and amplification factor of Singh Durbar Area in Kathmandu. To this end the Microtremor records obtained in Kathmandu valley were analyzed following Nakamura technique which is based on computation of spectral ratio between horizontal components and vertical components of micro-tremor measurement. The results obtained from Microtremor measurements were compared with the result from borehole data analysis. The results shows that, Microtremor measurement is useful to determine predominate time period with very acceptable reliability in the range of 1.02 sec to 1.93 sec in the study area.

The results show that the predominant time period is in the range of 1-2 sec and the *amplification* factor is above 1.0 in many places. The results are useful for urban *planners, building*

designers and geotechnical engineers as it shows that some *structures might experience* resonance during earthquake because of their time period *being close with that of the* ground.

Thesis Title: **STRENGTH AND PERMEABILITY CHARACTERISTICS OF NATURAL AGGREGATE FOR GRAVEL WEARING COURSE IN LOW VOLUME TRAFFIC ROADS**

Submitted by: **Ram Bahadur Poudyal**

Supervisor: **Mr. Padma Kaddka**

ABSTRACT

At present the National Road Network has altogether 15,308 km roads, including 3,646 km gravel and 7,140 km earthen roads. The Earthen road needs to be upgraded to gravel road for which natural gravel materials have traditionally been used. The inadequate proportion of binding material or lack of binding material in gravel does not fulfill the requirement of strength and stability. So the properties of gravel can be enhanced by the mechanical stabilization bringing the poorly graded material to the well graded. Laying of sub base with non plastic gravel or having plasticity index very low to the earthen road is in practice. For the low volume traffic road instead of sub base, gravel wearing course can be laid with increased fines contents and increased plasticity index. The Geotechnical properties of wearing course gravel can be enhanced by fulfilling the gradation requirement specified by Department of Road.

As per the various research papers and specifications of DOR, Nepal the fine should lie between 10% to 40%, Plasticity index in between 15 % - 35 % and soaked CBR value should not be less than 30% for Gravel wearing Course.

In this research paper, *soil* samples were collected from Nuwakot district of Nepal; three samples were investigated for preliminary tests i.e. Reject Index, Grading Modulus, LAA, Flakiness and Elongation Index. Ideas about the strength and limit of *gradation* of the samples were first found out and the samples were then recommended for further tests based on the results of the preceding test. Out of three samples, one *sample was not* observed with necessity of further tests from the preliminary examination and the remaining two samples were tested. Out of them one was tested directly adding the fines and other was prepared mixing the fine in different proportions. The mixes were tested by modified compaction method. The soaked CBR tests was carried out for both samples. Effect of fine to the permeability characteristics was also determined for the controlled sample.

The plasticity index of Samari (WC II) was found to be only 4.1 which is the lower than the value specified by *DOR, Nepal.* However the range is within the limit specified by TRL.

Similarly, dry density, optimum moisture content and soaked CBR values are: 2.25 gm/cc, 6.0% and 70% respectively. The LAA value was found to be **64.2%** which is not suitable for wearing course material. Flakiness index and elongation Index of the *sample* was found to be 34.73% and 44.05%.

Thesis Title: **COMPRESSIBILITY AND FRICTIONAL RESISTANCE OF VARIETY SAND IN DIFFERENT RELATIVE DENSITY**

Submitted by: **Laxman Babu Sedhai**

Supervisor: **Mr. Indra Prasad Acharya, Mr. Padma Kaddka**

ABSTRACT

In this study, one-dimensional compression behavior of Bagmati, Bishnumati andTrishuli sand is studied with the use odometer test at different relative density. Oedometer test done on dry sand is used to calculate the Compressibility. Constant head permeability test is carried out to develop the relation between void ratio and permeability (k). Direct shear test is carried out on the sands to study the variation of friction angle with relative density, gradation, Particle shape etc.

Specimens prepared with initial relative densities ranging from loose to dense are subjected to normal loading. Finally an attempt was made to bring the available information on physical properties of various sands at one place and to study variation of & e_{max} with e_{min} and (e_{max} - e_{min}) with coefficient of uniformity. Furthermore available on stress-deformation behavior of verities

of sands, both in triaxial and - has been reviewed to highlight the influence of crushing stress on the of different sands.

Hie Shear strength parameter along with dilatancy characteristics of both the sand is also studied. Plot of permeability against permeability function is also incorporated in tins study.
Finally Bagmati, Bishnumati and Trishuli sand is compared for each of the above mentioned p**r**operties.

Thesis Title: **NUMERICAL (FEM) ANALYSIS OF STRESS AND DEFORMATION AROUND AN UNDERGROUND EXCAVATION IN ROCKS USING ELASTO-PLASTIC APPROACH**

Submitted by: **Arvind Kumar Jha**

Supervisor: **Prof. Dr. Akal Bahadur Singh**

ABSTRACT

A simple numerical procedure 'for calculating the distribution of stresses and deformations around a circular tunnel excavated in a Mohr-Coulomb or generalized Hoek-Brown rock mass is proposed. The rock mass is assumed to be brittle plastic for Hoek-brown yield criterion and perfectly plastic for Mohr-Coulomb Criterion. For the elastic-brittle-plastic analysis of circular openings in an infinite Hoek-Brown medium, the existing analytical solutions were found to be incorrect. These methods, however, are based on simplifying assumptions with respect to geometry, material behavior and boundary conditions. So, analytical solutions can be rarely of practical concern to rock mechanics problems. As rock consists of complex formations and exit a wide range of behaviors, the analytical methods provide only approximate solutions. Hence, a conceptual tool, using numerical methods called Finite Element Method (FEM)

has been generated and OSed for realistic prediction of the behavior of the complex underground excavations in rock mass at various in-situ stress conditions.

The closed-form solution is validated by using the finite element method. In the finite element analysis, the constitutive model frequently used in numerical calculations of tunnel excavation is linear-elastic perfectly plastic Mohr-Coulomb (MC) failure criterion. Generally, this leads to shallower and wider surface settlement than those observed experimentally. In this research, constitutive model is implemented in a two-dimensional *simulation of* an underground excavation in a plane strain: a linear-elastic perfectly *plastic (the* Mohr-Coulomb model) model. Stresses and deformations of different shapes of *tunnels* using these constitutive models implemented in commercial software *(PLAXIS) are* evaluated.

Further, *numerical* procedure based on finite element method (FEM) for the analysis of bolt-grout *interactions is* introduced. The finite element procedure incorporates elastic- plastic concepts with *Hoek and* Brown yield criterion and has been applied for rock mass using the same *PLAXIS* software.

Thesis Title: **EFFECT OF GRAIN SIZE ON MECHANICAL BAHAVIOR AND FRICTIONAL RESISTANCE OF BISHNUMATI SAND AND OTTAWA SAND**

Submitted by: **Ram Prasad Ghimire**

Supervisor: **Prof. Dr. Ram Krishna Poudel**

ABSTRACT

In this thesis, mechanical and frictional resistance behavior of Bishnumati and Ottawa sand at different grain size was studied with the use of sieve analysis, permeability test, direct shear test, oedometer test. The important role of the particle size has been carried out to evaluate these behaviors.

The sample specimens, with grain size ranging from 2 mm to 75 micron for both Bishnumati and Ottawa sand were prepared by sieve analysis. Constant head permeability test was carried out to develop the relation between void ratio and permeability. The result showed that permeability of Ottawa sand is more than Bishnumati sand. Direct shear test was carried out in three different magnitude of normal stress to study the variation of friction angle (O) with grain size. Shear strength and frictional angle of Ottawa sand was found more than that of the

Bishnumati sand. The oedometer test was done on sample specimen to study the deformation behavior. Compressibility of Bishnumati sand was found approximately two times higher than that of Ottawa sand. Coarse soil is obtained to be more compressible than fine soil under large stress. Similarly, compressibility of high graded particle was found more than that of low graded particle.

Finally, results from the above mentioned study was drawn and comparison with the available data made, and it was observed that the particle size has substantial influence on the mechanical and frictional behavior of Bishnumati and Ottawa sand.

Graduation Year 2012

Thesis Title: **PILED RAFT INTERACTION UNDER DIFFERENTIAL LOADING CONDITION**

Submitted by: **Chandra Dev Bhatt**

Supervisor: **Prof. Padma Khadka**

ABSTRACT

Due to high rate of urbanization in recent years, there is a need of rapid infrastructure development in the country. In this perspective, the high- rise buildings are the first infrastructures to be built for which use of piled raft foundation is inevitable because the raft foundations alone could not satisfy the requirements of bearing capacity and settlement. Piled raft can be loaded under differential loading to suit the requirements of buildings under various units (blocks) within same building. In recent years many buildings have been built using piled raft foundations, without much study on load sharing behavior, and settlement behavior, under differential loading conditions.

For large load coming from superstructure, the combination of pile and raft is very useful over using conventional mat foundation or pile foundation alone. Piled raft can be used to transfer loads to the deeper strata using piles and to reduce the

overall and differential settlement. In non-uniform loading conditions, piles with different sizes can improve the performance of the foundation. This combination is very useful for the low bearing capacity soil and reducing excessive settlement. From past research it has been found that in piled raft subjected to a non uniform loading, the use of piles with different lengths and diameters can improve the performance of the foundation. Similarly by strategic placing of piles under the areas of higher settlement can decrease the settlement. In this research factors like pile diameter, pile spacing, pile arrangement, length of pile, thickness of pile cap have been studied for vertical loading under differential loading condition for design optimization. 3-D models for piled Raft foundations under differential loading condition is prepared in Computer Software SAP 2000 V14 based on finite element method, under various soil condition and loadings by using springs for representation of soil and pile. Soil properties and Loads are appropriately assumed for the analysis. A study with parametric variation is attempted to understand the behavior of piled raft under various influencing parameters over using conventional piled raft foundation with similar spacing, length and diameter. Emphasis is given on load sharing and settlement behavior. Due to various constraints such as time, and availability of geotechnical software other interactions are not given much emphasis.

Thesis Title: **REGAIN OF SHEAR STRENGTH OF KALOMATO SOIL IN KATHMANDU VALLEY (SANEPA, MAHARJGUNJ, AND SOALTEEMODE AREA)**

Submitted by: **Dibangar Khoteja**

Supervisor: **Prof. Dr. Ram Krishna Poudel**

ABSTRACT

The characteristics of soil not only depends on the index property of soil, but also depends on the external stresses, historical events, environment changes and can aging with time. An undisturbed soil, which has a natural structure under equilibrium condition, will lose its load carrying strength i.e. shear strength if it is disturbed or remolded. This effect of disturbance may be substantial to that may make the soil to behave like a liquid. Remolding causes destructions of balanced particle structure. As a result the effective stress of soil and shear strength is reduced. A remolded soil regains its strength with time. After the removal of external forces or disturbing stress the soil will be in imbalanced condition and try to come to a new equilibrium condition. With time, interparticles arrangement, adsorbed water structure and distribution of ion get adjusted. The effective stress of soil is increased and finally there will be increase in shear strength with time. This phenomenon of regain in soil properties

in a remolded specimen is known as the thixotropic characteristics of soil. Thixotropic behavior is a natural response of a soil structure change in ambient conditions. The soil may require long time i.e. equal to some geological age to regain the full original strength. Thus Study of strength gain of remolded soil with time at unaltered moisture content and density seems to be a need with references to remolded strength and undisturbed strength.

Kalomato is an organic deposit having characteristics low shear strength, high compressibility, low permeability, low bearing capacity, low specific gravity, low density and high atterberg limits. The soil is a major deposit in Kathmandu valley, which is found at different depth in different layer. So due to booming construction in Kathmandu valley, it is necessary to study its thixotropic characteristic of soil to analyze the skin friction development around a pile, to successfully design high rise building which is arising in Kathmandu valley in rapid pace. Study of such regain in shear strength due to thixotropic property could have a large application in the design of piled raft foundation.

In this research work the thixotropic characteristics of Kalomato soil in Sanepa, Soalteemode and Maharajgunj area is studied and

the results are found to be similar to previous studies in organic soil. The regain in shear strength is found to be in the range of 16.76% to 24.44 % to tha of undisturbed hsear strength in 90 days.

Thesis Title: **INFLUENCE OF RELATIVE DENSITY ON THE CHARACTERSTIC OF SHALINADI RIVER DREY SAND IN DIRECT SHEAR TEST**

Submitted by: **Kalpana Adhikari**

Supervisor: **Prof. Padma Khadka**

ABSTRACT

This thesis is concerned with understanding the stress-strain and strength characteristics of Shalinadi river sand, a quartz sand, and the comparison of several existing flow rules developed. In this research, the historical development of the stress - dilatancy theories is briefly reviewed The generalized stress - dilatancy behavior of sand is presented. Extensive data of strength and dilatancy of Shalinadi river sand in direct shear at different relative densities and normal pressures are collated.

A total of 15 tests were carried out by using conventional direct: shear test apparatus. These tests were performed and correlation between relative density and angle of shearing resistance clearly showed that dense sand posses greater shearing resistance. However this tendency reduced with increasing normal pressure.

The critical state angle of shearing resistance of soil which is shearing at constant volume is principally a function of mineralogy and can be determined experimentally and by using flow rules.

Experimental data from direct shear tests were analyzed and interpreted to find Stress- Strain curve, Volume change behaviour, Angle of shearing resistance, Critical state angle, Principal stresses and Plain strain angle of friction by using both conventional and flow rule analysis. The relation between peak angle of shearing resistance and maximum angle of dilation was also developed for this particular sand. The Plain strain angle of friction was determined from the Critical state angle of friction and Angle of dilation. Results of both conventional and flow rule analysis were compared which seemed more similarities with few differences.

The overall finding also provides a reasonable measure of angle of shearing resistance, plain strain angle and the angle of dilation for our local sand (Shalinadi River sand), at different relative density and mean normal stresses, although data were crude from conventional direct shear test.

Thesis Title: **ASSESSMENT OF LIQUEFACTION SUSCEPTIBILITY OF TRIBHUVAN INTERNATIONAL AIRPORT**

Submitted by: **Kiran Chaulagain**

Supervisor: **Prof. Padma Khadka**

ABSTRACT

Nepal lies one of the world's most seismically active zones. It lies between big Eurasian and Indian plate. So most of the earthquakes are occurred in Himalayan range of Nepal. Earthquake produces different losses which are known as seismic hazards. The most important seismic hazards are Structural Hazards, Liquefaction, Landslides, Retaining structure failure, Lifeline Hazards, Tsunami and Seiche Hazards etc.

The study is concerned with Liquefaction hazards at Tribhuvan international airport situated in Kathmandu valley. Main parts of airport are runway, taxiways, hangers, parking, terminal building, communication towers etc. When the ground liquefies in an earthquake, sand or silty materials saturated with water behave like a liquid, causing pipes to leak, roads and airport runways to buckle, and building foundations to be displaced etc. Factors which affect the liquefaction susceptibility of area are Grain Size, Grading of soil, Relative density, Compaction of soil, Depth of

water table, Depth to thickness of strata, Previous Liquefaction etc.

For the Assessment of Liquefaction Susceptibility of Tribhuvan International Airport Boreholes and SPT test were conducted to find out grain size of soil, grading of soil, layer and depth of soil, depth of ground water table, bearing capacity of soil, relative density of soil, angle of shearing resistance etc. Therefore an attempt has been made to analyses liquefaction susceptibility of the area. The quantitative analysis for boreholes will be made with sufficient geotechnical information following method of J.M**.** Idriss and R. W. Boulanger.

Thesis Title: **EVALUATION OF LIQUEFACTION POTENTIAL IN KATHMANDU VALLEY BY ENERGY APPROACH**

Submitted by: **Krishna Kumar Mahato**

Supervisor: **Prof. Dr. Ram Krishna Poudel**

ABSTRACT

The main Objective of this research is to evaluate the liquefaction potential of different part of Kathmandu valley by energy approach. Liquefaction is defined as the rapid loss of shear strength in cohesionless soils subjected to dynamic loading, such as from an earthquake. Liquefaction is a very critical issue in case of cohesionless soil which causes failure of many structures, loss of huge investment and loss of human lives. There are many methods for evaluating the potential of liquefaction and among them Energy Approach is selected here for this study. This method was developed in 1990 by K.T.LAW, Y.L.CAO (Canada) and G.N.HE (China) based on laboratory tests and field observation data obtained in past major Earthquakes. The relation was obtained by evaluating various parameters from 136 sites involved in 13 major Earthquakes over the world.

In this study three major sources of earthquake, identified by Department of Mines and Geology, Nepal and JICA team are taken in consideration. They are Kathmandu Valley (KV) local Earthquake (M=5.7), North Baghmati Earthquake (M=6) and Mid Nepal Earthquake (M=8). Other data required for this research work are collected from various institutions as well as previous research reports and technical Journals. Total number of 90 Locations with 434 boreholes of different depth and about 4000 SPT values are included for analysis. Separate analysis for each source is done and then combined effect of all cases is also assessed. The results obtained from the analysis are presented in table as well as in maps prepared on GIS.

From this study, it is seen that many parts of the Kathmandu Valley are susceptible to liquefaction for the entire selected scenario. Liquefaction potential due to KV local earthquake is higher than other earthquake though the earthquake has low magnitude. This is due to short distance and shallow focal depth. The study shows that liquefaction potential not only depend on magnitude but also highly depend on source to site distance and focal depth of the earthquake. Hence all three parameters i.e. Magnitude, source to site distance and focal depth of earthquake must be considered during the evaluation of liquefaction potential.

Thesis Title:	**ZONING OF LIQUEFACTION POTENTIAL FOR KATHMANDU VALLEY**
Submitted by:	**Mandip Subedi**
Supervisor:	**Prof. Dr. Ram Krishna Poudel, Prof. Padma Khadka**

ABSTRACT

Liquefaction is one of the primary causes of an earthquake which may be responsible to excessive settlements and ultimately damage of buildings, roads, pipelines and infrastructures. Kathmandu valley is highly prone to earthquake disaster due to active tectonic setting around it.

Results of an extensive analysis for determination of liquefaction hazard of Kathmandu Valley at different locations are addressed here. The widely accepted Youd et al (2001) methods are used in calculation of FOS against liquefaction for earthquake magnitude of 8.0 and acceleration of 0.3 g as reported in JICA (2002). The findings are compared with liquefaction hazard map of Kathmandu Valley prepared by JICA and UNDP/MOHPW and from the comparison it is found that the map prepared by UNDP/MOHPP seems to underestimate the geological parameter and other strength of soil/sand. In contrast to the map prepared

by UNDP/MOHPP, the hazard map prepared by JICA overestimated the geological and strength parameter.

Various correlations like CRR/CSR versus $Ni_{(6}o)cs$, CRR Vs fine content has been obtainedfor Kathmandu valley basin.. In general, the value of CRR increases with increase in fine contents. The relationship between fine content and Cyclic Resistance Ratio, CRR developed for Kathmandu Valley basin is very similar to the relationship developed by many others authors.

An imaginary bore hole of depth 16.5 m having homogeneous layer was assumed and evaluated to find threshold value of SPT-N and fine content for no liquefaction condition. It was found that the top layers of around 4 m thickness do not liquefied when SPT-N value is more than 20 and FC is more than 15.

From the analysis it is observed that Maharajgunj, Gaushala, Duwakot, Gothatar and Changunarayan are the most hazardous area for liquefaction in Kathmandu valley some part of Kritipur municipality are leveled as medium vulnerable to liquefaction susceptible. The investigation made by UNDP/MOHPP and JICA is found non- reliable. Liquefaction potential is high in sandy layer, less SPT value and high watertable area. Finally, the

author of this work believe that liquefaction potential maps would assist the designers in taking suitable decision regarding necessary sub-soil treatment at different locality based on the design Peak Ground Accelerations. It is obvious that a further study to determine in-situ cyclic stress ratio by means of site-specific ground response analyses might result in more comprehensive estimates to be used for liquefaction assessments, especially when combined with cyclic triaxial test results.

Key Words: Liquefaction, SPT, CSR, CRR, Bore hole

Thesis Title: **FINITE ELEMENT ANALYSIS OF CONCRETE GRAVITY DAM**

Submitted by: **Manoj Baral**

Supervisor: **Prof. Padma Khadka**

ABSTRACT

The problem of solving a two dimensional problem using finite element method (FEM) is addressed in this research work. The analysis has been done by writing finite element code using commercially available MATLAB software and compared the result obtained with commercially available finite element software like Phase 2 V6. The two dimensional plane strain condition has taken for the analysis. The Lagrange interpolation function has been used as a shape function for two dimensional triangular elements. The result obtained from finite element programming and Phase2 shows the same values and same distribution pattern of deformation and stress for the same loading and material condition.

Thesis Title: **DESIGN OF TUNNEL SUPPORT SYSTEM: SHOTCRETE VERSUS ROCK BOLTS IN MIDDLE MODHI HYDROELECTRIC (MMOHP)**

Submitted by: **Milan Paudel**

Supervisor: **Prof. Padma Khadka**

ABSTRACT

Nepal is a land locked country with diversified topographical and geological features. Most of its parts are covered by the low hills to high Himalayas. The Himalayan geology is one of the technically youngest geological formations in the world. Except the young formations, rock mass in the Himalaya is highly weathered, fractured and weak in strength and is thus challenging for the construction of underground structure like tunnel and caverns especially for the development of hydropower project. On the other hand, economic design is the utmost importance for the developing countries like Nepal for underground development project. Middle Modi Hydropower Project (MMoHP) is also facing the problem with weathered, fractured and weak rock mass for the construction of headrace tunnel.

This research work is carried out in four steps. In the first there steps, tunnel lining design by empirical, numerical and analytical

method and in last step, economic analysis has been performed based on different lining method.

In the first part, the support system analysis of Middle Modi Hydroelectric Project (MMoHP) is performed by Empirical Method for the headrace tunnel. The rock support class according to the Q-value is prepared for the whole section of headrace tunnel.

In the second part, numerical analysis is performed for the support analysis for two lining system; conventional rock bolts and shotcrete versus Steel Fiber Reinforced Shotcrete (SFRS). For the analysis, beam theory is used and the corresponding stress calculation and support analysis has been performed by PHASE Software. Two sections before and after the weakness zone were taken as sample sections i.e. Chainage 1+000 and 2+400. From numerical analysis (plastic condition), the maximum displacement around tunnel contour was found less than 3 mm in first section and 50mm in second section. The value of strain was found less than 1%, which indicates that rock mass suffers less stability problem. From the analysis, the change in thickness of the shotcrete in case of shotcrete and rock bolts and in case of shotcrete only has been determined.

In the third part of the analysis, analytical calculation is performed by using the potential energy method for the design of tunnel lining. Rock pressure has been derived from Protodaikonov's Theory. In potential energy method, it is assumed that all the external loads are known and can be quantified in terms of some mathematical expression and concrete lining is placed just after the excavation to take up all the load and deformation so that it acts as temporary as well as primary support. In this method, all external loads and other design parameters such as ground reaction, lateral active earth pressure and vertical rock pressure has been determined and bending moment M at tunnel contour is determined by superimposing the moments due to all loads. Finally the monolithic concrete lining for tunnel has been proposed to resist that moment using the limit method of design of reinforced concrete. The thickness of tunnel lining found from the analytical method is somehow similar with numerical analysis.

In the last step, economic analysis is performed based on the different lining methods.

Finally the result from all three methods has been studied and the conclusion has been made as; Steel Fiber Reinforced Shotcrete (SFRS) can be taken as the permanent lining element for tunneling in weak rocks by minimizing the use of rock bolts;

Steel Fiber Reinforced Shotcrete (SFRS) will be more cost and time effective than conventional wire mesh shotcrete and rock bolts.

It is strongly recommended for the continuous field monitoring during the tunneling work and skilled manpower team and corresponding equipment are necessary for each cycle of tunneling to obtain the better tunneling progress with optimum safety and economy.

Thesis Title: **EVALUATION OF STRESS - DEFORMATION CHARACTERISTICS ON FOUNDATION SOIL CONSIDERING THE INFLUENCE OF GROUND WATER FLUCTUATIONS**

Submitted by: **Narayan Prasad Acharya**

Supervisor: **Prof. Padma Khadka**

ABSTRACT

Every civil engineering structures are mainly built in soil, by soil, or into soil. The soil is multi- phase material having diversified physical as well as engineering property. Its behavior under the action of external loads is very complex. The stress strain characteristics of the foundation soil depends upon the various parameters such as physical features of foundation, amount of total and differential settlement, relative density in case of granular soil and consistency in case of cohesive soil, position of ground water table etc.. The level of ground water table may fluctuate with time due to various factors such as rainfall pattern, land use pattern of the adjoining and catchment area, degree of extraction and/ or recharging of ground water. The property of foundation soil may vary accordingly.

Many of the big cities on the world are on the soft ground foundation. Kathmandu, the capital of Nepal is also founded on alluvial/ lacustrine deposits of more than 300m depth. Unplanned urbanization and rapid growth of population in Kathmandu valley lead to the over pumping of the ground water which leads to the over exploitation of the ground water and result in depilation of ground water table day by day. The lowering of GWT in Kathmandu valley creates a great concern to the region. This may affect the stress- deformation characteristics of foundation soil and ultimately may leads to different adverse geotechnical problems.

To study the stress- deformation response of foundation soil by considering the influence of water table fluctuations, Geotechnical software Phase2 based on finite element method is used for modeling soil domain in this thesis work. The size and boundary condition of model is fixed based on size of pressure bulb and the boundary effects. In modeling, three different types of footing namely: strip, mat and circular founded each on four different types of soil namely: soft clay, stiff clay, dense sand and clayey sand having typical geotechnical properties subjected to appropriately assumed load are considered. The land subsidence analysis typically for clay strata, the settlement analysis and total effective stress analysis are made and

interpretation is made accordingly. Also the similar analysis is made for actual soil profile of Gwarko site, Lalitpur of Kathmandu Valley.

From the study it is found that the actual position of GWT at instant of loading is utmost important in predicting the amount and rate of settlement. So, reliable information on ground water level within the zone of influence of a foundation is vital from the point of view of foundation design and construction. GWT position could be properly monitored during sub-soil exploration.

It is found that the land subsidence problem is more prominent in soft clay strata, moderate in medium clay strata and minimal in stiff clay strata. To safeguards from adverse effects that may arise from possible land subsidence, the better solution is to maintain the level of GWT within reasonable level by artificial recharging of sound water, safe extraction of ground water and controlling illegal pumping of ground water. However in case of granular soil, the lowering of GWT is beneficial from foundation stability point of view. After *loading, settlement at FL increase slightly* if GWT comes closer to foundation level and increased considerably if raised further above FL. Proper surface as well as sub-surface drainage management may be a good solution to maintain level of GWT well below the footing level for long

term sustainability and overall stability of any important civil engineering structures.

To properly address the issue of stress-deformation response of foundation soil with ground water table fluctuations, it is recommended to model the stress-strain behavior of foundation material as accurately as possible to solve foundation engineering problem by using sophisticated constitutive models so that designed foundation system satisfy strength limit as well as desired serviceability limits; and conduct in- situ field test for stress and deformation measurement under design loading to know actual response of site specific foundation soil.

Thesis Title: **TUNNEL SUPPORT DESIGN TUNNELING IN SQUEEZING ROCKS USING ELASTO-PLASTIC APPROACH**

Submitted by: **Pranil Parajuli**

Supervisor: **Prof. Dr. Akal Bahadur Singh**

ABSTRACT

In tunnelling through weak rocks as schists, micaceous rocks, it is important to attempt to obtain reliable estimates of potential tunnelling problems as early as possible. The stability of an underground excavation depends upon the structural conditions in rock mass and also upon the relationship between the stress in the rock and strength. This enables the designer to focus on the selection of optimum routes and to devote the appropriate resources to the investigation of those areas in which tunnelling problems are anticipated.

Different methods are used for identification and quantification of squeezing; the available empirical and semi-empirical approaches are accessed in order to anticipate the potential of squeezing tunnel problems. As rock consists of complex formations and exhibit a wide range of behaviors, the analytical methods provided some approximate solutions only. But also, analytical solution was found suitable in solving rock mechanics

problems. The use of numerical methods for the simulation of different models of behavior and for design analysis of complex excavation and support systems is considered.

Rock mass classification approach is used as first estimation of support system required in *underground excavation works. The data required* for classification are collected from Nyadi Hydropower Limited, Buddhanagar (Nyadi Hydropower Project, 30MW, Lamjung). RQD, Q value and RMR, all were found to be extremely low for the Schist found in 104m depth for a*ccess* Tunnel of the same project.

The failure model frequently used in numerical calculations of tunnel excavation and stability analysis is Generalized Hoek Brown Failure Criteria. The Hoek Brown Parameters used for the failure criteria are taken from the Chart and analyzed. Stresses and deformations of a standard shape of tunnel and D-shaped tunnel using the Hoek-Brown constitutive models ire evaluated and further recommendations in design of support system are provided. Phase Modelling has been used for elasto-plastic solution to the squeezing problem.

Thesis Title: **OPTIMATION IN SIZE OF D-SHAPED TUNNEL DUE TO BLASTING IN TERMS OF WIDTH TO DEPTH RATIO ON THE OVERALL CONSTRUCTION COST**

Submitted by: **Raja Ram Khadka**

Supervisor: **Prof. Padma Khadka**

ABSTRACT

This thesis entitled **"Optimization in size of** D**-shaped tunnel due to blasting in terms of width to depth ratio based on the overall construction cost"** is based on the 2D modeling. Whole research work is concerned in blasting damage control so that the blasted surface is smooth and hence the least will be the cost of combined support system and lining.

The design of support system is much more art of science. The principal objective of the underground support system is to help the rock mass to support itself. The underground structure-tunnel is being used for transportation purposes due to increasing urbanization, economical and geological conditions. An investigation of the cost associated with tunnel in rock indicates that the combined support and lining system represents % to Vi of the total cost of project. It is obvious that major savings may be recognized by even slight improvement of support system

which is utmost importance for the under-developing countries line Nepal.

The unplanned and non-analyzed use of explosive for blasting may result serious structural damage in rock and hence needs stiff support system which is obviously expensive as well. As a result the overall construction cost of the project will be costly. Hence to get rid of that problem, this research work has been conducted. 2D software, JKSimBlast (blasting software) is used for the research work. Different charts have been prepared using this software along with the cost estimate. They are attached in this report as well. Then after, appropriate lining and support systems are selected. The overall per meter cost is obtained for different models for different cases of rock and the model giving the least cost is recommended as the optimum one. From the calculation, it was found that optimum width to depth ratio of tunnel is around 1:1for a given area in any cases of rock.

Thesis Title: **EFFECT OF STONE DUST ON STRENGTH BEHAVIORS OF REDDISH RESIDUAL SOIL**

Submitted by: **Rajan Kadariya**

Supervisor: **Prof. Dr. Ram Krishna Poudel**

ABSTRACT

The Strength of poorly graded residual soils can be increased upto the level of good strength by addition of quarry stone dust as a additive which is cost effective Due to the high demand for aggregates for construction purposes, aggregate crushers are very common. Out of the different quarry wastes, quarry dust is one, which is produced in abundance. About 20-25% of the total production in each crusher unit is left out as the waste material-stone dust. Bulk utilization of this waste material is possible through geotechnical applications like embankments, back-fill material, sub-base or use in a sub- base material as a admixture material and the like.

This research include the effect of stone dust combine at different percentage on a reddish residual soil, the test results such as index properties, Proctors compaction, OMC, shear parameters, and CBR values obtained on residual soil mixed at different

proportions of stone dust (admixture) are investigated and reviewed.

Addition of admixture is commonly resorted to in order to improve the strength behaviors of residual clay deposits. Comparatively a fewer studies have been focused on effect of stone dusts on strength behaviors of residual clay soils.

Soil mixes were prepared by adding the quarry stone dust at an increment of 5.0% in residual soil sample. The maximum density of soil mix increases upto 1.765 gm/cm2 at stone dust content of between 25% to 30% and then decreases with increased amount of stone dust, whereas the optimum moisture content of soil mix decreases continuously upto the limit of 25% of stone dust content and then decreases with further increase in stone dust content The shear strength parameter of soil mix, i.e, Cohesion of the soil decreases with increase in stone dust where as angle of internal friction (O) increases continuously with increase in stone dust, ultimately shear strength of soil mix is increases with increase in percentage of stone dust. The soaked CBR values increases rapidly on addition of stone dust upto 25%, reached to the optimum value of 18.52% from that of 8.0% of natural soil sample, and then decrease on increase in stone dust content. By use of optimum proportion of stone dust, as a additive,

improvement of strength properties of poorly graded residual soil has been obtained with increased max. Dry density in control water content, increased in shear strength and CBR.

Thesis Title: **CORRELATION OF SHEAR STRENGTH OF SILTY SAND WITH SPT VALUE**

Submitted by: **Shankar Rimal**

Supervisor: **Prof. Padma Khadka**

ABSTRACT

The Standard Penetration Test is most widely used in-situ test over the world and most commonly used in sand and silty sand, while the direct shear test is one of the oldest strength test for soils.

This thesis is concerned with the correlation of shear strength of silty sand with SPT value. In this research, the historical development of the standard penetration test and direct shear test as well as analysis and interpretation were briefly reviewed. The observed as well as corrected standard penetration test value was presented. Extensive data of strength and dilatancy of same soil in direct shear at different void ratios and normal pressures were collected.

To perform these analyses, standard penetration test was conducted into a borehole up to 15m depth with interval of 1.5m and a total of 27 tests were carried out by using conventional direct shear test apparatus with dimensions of 5.1 cm x 5.1 cm x

1.80 cm to determine shear strength of same soil. Using the data obtained, correlation between standard penetration value and shear strength clearly showed that dense soil posses greater shearing resistance. However this tendency reduced with increasing normal pressure.

The overall findings also provides a reasonable measure of Standard Penetration Test value, angle of shearing resistance, and the angle of dilation for our local area soil, at different void ratio and normal stresses.

Thesis Title: **EFFECT ON THE STRENGTH OF NATURAL SOIL TREATED WITH VARIOUS PROPORTIONS OF CEMENT KILN DUST**

Submitted by: **Siddhartha Rimal**

Supervisor: **Prof. Padma Khadka**

ABSTRACT

Soils may be improved through the addition of chemical or cementitious additives. These chemical additives range from waste products to manufactured materials and include lime, Class C fly ash, Portland cement, cement kiln dust from pre-calciner and long kiln processes, and proprietary chemical stabilizers. These additives can be used with a variety of soils to help improve their native engineering properties. The effectiveness of these additives depends on the soil treated and the amount of additive used. Many studies have been done using different additives but cement kiln dust (CKD) is not used.

Cement kiln dust (CKD) is a fine powdery material similar in appearance to Portland cement and is a byproduct during cement construction. In this particular research the effects on the strength of two samples of natural soil treated at various proportions and curing period with cement kiln dust (CKD) is studied. The rate of

increase of unconfined compressive strength of the un treated soil sample (ML) is not very high up to 28 days (0.346kg/cm^2 at first day to 1.65 kg/cm^2 at 28th day).Similarly the rate of increase of unconfined strength of un treated soil sample (CL) is also not very high up to 28 days (0.318 kg/cm^2 at first day to 1.531 kg/cm^2 at 28th day) .The addition of cement kiln dust led to the increase in unconfined compressive strength for both soil samples. The unconfined compressive strength of 2.5% cement kiln dust treated soil sample (ML) tested immediately after preparing the sample is 0.761 kg/cm^2, whereas for 10% cement kiln dust treated soil is found to be 10.552 kg/cm^{2}at 28 days. Similarly the unconfined compressive strength of 2.5% cement kiln dust treated soil sample (CL) tested immediately after preparing the sample is 0.692 kg/cm , whereas for 10% cement kiln dust treated soil is found to be 10.156 kg/cm at 28 days. In case of immersed samples non treated and 2.5% CKD treated samples disintegrated for both soil samples and only 5%,7.5%, 10% CKD treated soil samples showed some increase in unconfined compressive strength. As the percentage of CKD increases, there is decrease in the reduction of unconfined compressive strength of CKD treated immersed samples with respect to CKD treated dry samples.

Thesis Title: **BEARING CAPACITY ZONATION OF URBAN AND SUB-URBAN AREA OF KATHMANDU AND LALITPUR DISTRICTS**

Submitted by: **Sunil Kumar Mahato**

Supervisor: **Prof. Padma Khadka**

Abstract

Bearing capacity of soil has a great influence in designing the foundation of building and other structures. The building code have been developed by almost all developed countries of the world, these include guideline specifications for design/ construction, *building* regulations etc. Some have even prepared their bearing capacity zonation to be used by engineers and architects. Such zonation map for Kafhmandu valley does not exist.

With the speedy urbanization within Katfamancfai Valley Use building construction is **emerging in** a rapid pace. The essence of constructing t»H_3 high rise and multi-storied **buildings is** a must as inadequate land remaining in the valley. For this, bearing **capacity of soil** should be checked prior to construction for the prevention from **settlement and collapse**

The *prepared* bearing *capacity* zonation map possibly will be useful during preliminary *planning, design and feasibility* studies of

engineering/geological project. Such maps would be extremely supportive for the enthusiastic engineers and geologists with **significant** *and* considerable savings in time and expense. The zonation map will **facilitate the design** engineer for preliminary design of foundations, feasibility studies, **planning of** detailed investigation programs for major projects as well as the **preparation of** tentative cost estimates of various projects, formulate the necessary **appraisal and** *design* recommendation for projects.

A *bearing capacity* zonation map of Kathmandu and Lalitpur districts is prepared in *this study*. Different analytical and empirical correlations have been used to estimate *the bearing* capacity at different depths from existing ground level and these methods are *also* compared. It is concluded that a considerable difference in bearing capacity *using different* methods are found and for the zonation, least value of bearing capacity *has been used.* Based on the results, the areas with very low bearing capacity are *delineated. Though the* mapping has been produced for shallow foundation case, a deep foundation will be necessary for some part of the area where bearing capacity is too low. As the study does not consider ground water able corrections, some recommendations regarding ground water table correction is provided.

Thesis Title: **CORRELATION BETWEEN CBR VALUES AND MODULUS OF RESILIENCE OF SOIL**

Submitted by: **Uday Raj Neupane**

Supervisor: **Prof. Padma Khadka**

ABSTRACT

Sub grade soil characterization in terms of Resilient Modulus (M) has become crucial for pavement design. For a new design, Mr Values are generally obtained by conducting repeated loading test on reconstituted/undisturbed cylindrical specimen. The focus of this study is to develop empirical correlation between California Bearing Ratio (CBR) & Resilient Modulus (MR) of soil of Kathmandu and using equation in predicting resilient modulus of soil. The various literatures have shown that the resilient modulus test was conducted on soil in different countries but no any research has been conducted in Nepal. Therefore, in this research an attempt has been made to find the resilient modulus and CBR rating of the soil and attempted to correlate the findings of a laboratory measurement of resilient modulus and its CBR rating. For this purpose, laboratory test was conducted on soil of Kathmandu.

The cyclic Odometer test was conducted to determine resilient modulus of the soil. The repeated load test was conducted on saturated soil at different dry densities.

Specimens were prepared having different percentage of maximum dry density with corresponding water content. The compactness is subjected to normal loading as well as hysteretic and repeated loading patterns. The magnitude of the resilient modulus as well as CBR values of soil depends on several factors such as confining pressure, grain size composition and other.

The focus of the present study was to find the resilient modulus of the soil and to develop a new mathematical correlation between California bearing ratio & resilient modulus of the soil through laboratory test.

Graduation Year 2013

Thesis Title: **MODIFICATION OF SOIL CHARACTERISTICS BY THE USE OF TOPSEAL FOR AN UNPAVED ROAD**

Submitted by: **Aashish Dhakal**

Supervisor: **Prof. Padma Khadka**

ABSTRACT

Nepal is a country with low altitude of Chure to highest peak of the world Mt. Everest. Nepal after 10 yrs. of conflict is now growing and developing in every way. Road Network is the backbone for a development of the nation. Due to limited and controlled investment in every field, country has obstacles in the development of the road network. In these circumstances, any material relatively cheap, readily available, durable and compatible with the environment will be the best solution for the problems prevailed. The approach discussed in this thesis uses liquid chemical additive named Topseal to achieve soil stabilization in an unpaved road. It is commercially available product.

The goal of the research presented in this thesis is to test the impact of addition of Topseal on a soil type from Chitwan,

Vijaynagar. California Bearing Ratio (CBR) test, Unconfined Compressive strength test and Permeability Test were used to measure the effectiveness of the treatment of Topseal to Hie soil and as well as for its optimum content. Soil used in this research is inorganic silt of no plasticity (ML according to USCS) which is effectively stabilized using TopseaL Through the research conducted a new method of Road Constmciion material is tested for Nepal which produced about 500% improvement in the CBR values of the treated soil to untreated soil. The introduction of Topseal in the proposed ratio, soil permeability characteristics showed excellent improvement from permeable to nearly an impermeable state. In an immediate unconfined compressive strength test, the treated soil in the ratio of 1:9 showed 58% of improvement in comparison to untreated natural soil. Likewise, within a day in treated soil in ratio of 1:9, strength has increased about 11% to its immediate value. The result suggests us that with the introduction of Topseal rapid curing takes place allowing roads and runways to be constructed quickly and with minimal effort.

Traditional pavement design and construction practices require high quality materials to fulfill minimum construction standards. So, there is clear need for additives to reduce dust, improve all-weather possibility and minimize maintenance requirements in

rural road of Nepal. Topseal, a viable solution for stabilizing marginal soil, will be a promising new low-cost alternative to traditional construction materials in the rural road of Nepal.

Thesis Title: **EVALUATION OF GRADING ENVELOP FOR SUB-BASE MATERIAL**

Submitted by: **Ishwor Bahadur Rijal**

Supervisor: **Prof. Dr. Ram Krishna Poudel**

ABSTRACT

Due to the fast rate of development of the country, the trends in construction of Road networks are increasing rapidly. The constructed roads must be performed good quality as well as quantity. The performance of flexible pavements depends on many factors such as structural adequacy of the pavements, properties of materials used, traffic loading, climatic conditions and construction practices.

Sub-Base materials that meet specifications are getting more difficult in many regions of the country as per specified by Standard Specifications of Road and Bridge Works, DOR. In many cases, the local sub-base materials miss the specifications by small margins. As a result, higher quality materials have to be hauled long distances or additional binder materials are adding to meet the gradation of sub-base materials. This act would significantly increase the costs associated with roadway construction. Nowadays, we engineers used crusher run sub-base materials for getting the specifications specified by DOR which

may increase the project costs. The main aim of this research was to find out the minimum percentage of fines passing through 75 μ. required for sub-base materials that meets the specification specified by DOR.

For this Laboratory research, the samples were collected from the Indrawati riverbed materials at dolalghat, Sunkoshi riverbed materials at Sukute and Tamakoshi riverbed materials at dholi. From the Laboratory results, all the samples found to be non-plastic and the percentage of fines passing through 75 μ it was minimum as specified by DOR's specifications. But all the requirements specified by DOR's specifications except Loss Angeles Abrasion Value were met by the available fines content. Similarly, the geotechnical properties of the samples collected from Tamakoshi riverbed materials was analyzed by varying the percentage of fines content as 0%, 2%, 4%, 6%, 8% and 9.5% by following the median of the sub-base envelop specified by DOR's specification. From these results, the samples having 0% fines content also met all the requirements specified by DOR's specifications and found optimum at 6.6% fines content of the prepared samples.

Thesis Title: **CORRELATION BETWEEN SENSITIVITY AND ACTIVITY OF KALOMATO ON KATHMANDU VALLEY**

Submitted by: **Nisha Rijal**

Supervisor: **Prof. Dr. Ram Krishna Poudel**

ABSTRACT

The characteristics of soil not only depends on the index property of soil, but also depends on the external stresses, historical events, environment changes and can aging with time. The many natural phenomena and human made causes also can affect both index and engineering properties of soil. An undisturbed soil in earth developed its strength and properties, through many processes extended over long period after its formation. The soil may undergo through many cycles of imbalanced due to various phenomena before the restoration of equilibrium condition again.

From the previous research and investigation, it was found that Kathmandu valley soil (Kalomato) is an organic deposit having characteristics low shear strength, high compressibility, low permeability, low bearing capacity, low specific gravity, low density and high Atterbergs limits. The soil is a major deposit in Kathmandu valley, which is found at different depth in different

layer. So, it is necessary to study the comprehensive knowledge on the sensitivity characteristics and activity of kalomato in Kathmandu valley and the properties of soil affecting the sensitivity.

Undisturbed and disturbed samples were collected from two different sites at two different depths. The samples thus collected were preserved and tested in CMTL. The lab testing included index property test, organic content determination, consolidation test and unconfined compression test.

The result shows that the kalomato considered for this study has relatively lower organic content; Atterbergs limit value, high shear strength and low sensitivity than those obtained from previous research done in various part of valley. The sensitivity of the samples considered lies in between 3.92 to 7.07 and have the compression index value lies in the range between 0.34 to 1.01. The lower value of sensitivity might have been due to the high shear strength of the soil considered. The research is focused on the development of correlation between sensitivity and activity, as from different study of clay revealed that sensitive clay have low value of activity. The activity of the clay considered in the study also decreases with increase in sensitivity.