MSc Theses Abstract

Master of Science in Structural Engineering

Published by

Center for Applied Research and Development (CARD)
2013

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Published by
Center for Applied Research and Development (CARD)
Ananda Niketan, Institute of Engineering, Pulchowk Campus,
Tribhuvan University, Nepal
G.P.O. Box: 1915
Phone: 977-1-5521310

Design
Aadhaar Group Pvt. Ltd., Kupondole, Nepal
E-mail: info@aadhaargroup.com.np

Print

Padma Press, Kirtipur, Kathmandu, Nepal

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Graduation Year 1998

Thesis Title: USE OF LOCAL AND WASTE MATERIAL IN CEMENT CONCRETE

Submitted by: Netra Bahadur Karki

Supervisor: Dr. Mohan Prasad Aryal

ABSTRACT:

In the past, few decades various research works have been carried out in different parts of the world in connection with the utilization of local and waste materials in cement concrete. Only limited numbers of research works have been done about the uses of bamboo as reinforcing material and brick dust as mineral admixtures in cement concrete. Specially in our country no such researches studies have been found.

In this thesis (research work) the feasibility of using bamboo as an expedient material for reinforcement in concrete beam and brick dust as mineral admixtures in concrete beams and cubes, have been studied.

Various tests such as cube test, flexure test, durability test, pore refinement lest, heat of hydration, tensile strength test, compressive strength test, water absorption zest and others, have been carried out during the course of studies.

The test data have been analyzed and graphs have been plotted. Different analytical values have been calculated. Various analytical and experimental results have been compared.

The test results indicate that bamboo seems to be an appropriate alternative material for reinforcement in concrete. From the study it has been observed that the ultimate load capacities of bamboo reinforced concrete beams are of 80% to that of steel reinforced beams when cross sectional area of longitudinal bamboo reinforcement is only nine times that of steel.

It has been found that bamboo splint can take average tensile strength of 167 N/mm2 which is about 60% to that of mild steel. Use of bamboo reinforcement has increased the ultimate load carrying capacity of the concrete beam to 2.7 times to that of unreinforced beam.

The ultimate bond strength developed between the bamboo splints and concrete varied from 0.15 to 1.68 N/mm2. Studies have been shown that governing parameter in the bamboo reinforced cement concrete beam is bond strength between bamboo and concrete. Seasoned splints develop much higher bond strength than unseasoned splints. Natural protrustous as embedded nodes of splints, effective surface treatment of splints and higher concrete grade all lead to greater bond strength.

Similarly, with the replacement of cement by brick dust as mineral admixture in cement concrete in about 20 percent gives almost same flexural but higher compressive strength. The concrete cube with 20% cement replaced mineral admixture prepared from brick dust (BMA) shows 15 % more strength than concrete cube with Portland cement only.

The concrete with 20% BMA also shows good resistance to chemical attack specially on sulfate attack. They also show better pore refinement alter long period. Chemical compounds and lime reactivity strength of brick dusts have been found with in the range given for good pozzolanic material. The pore refinement and low heat of hydration have shown that the properties of concrete can be improved when brick dust has been used with combination of Portland cement.

Dumping of brick dust and brickbat have not only occupied the large acres of land but also create environmental problem. This problem can be reduced to a large extent by using these waste materials in cement concrete work. The mineral admixture (BMA) has good reddish colour. The mixture of Portland cement and BMA can be used as decorative cement.

Thesis Title: GEOGRID REINFORCED SOIL STRUCTURES FOR SLOPE STABILISATION

Submitted by: Binod Adhikari

Supervisor: Dr. Mukunda Singh Pradhan

ABSTRACT:

Geosynthetic reinforced soil structures are being increasingly used as a replacement of conventional earth retaining structures all over the world. Production of high strength polymer reinforcements in the form of geogrids created favorable condition for the construction of higher walls. Intensive researeh works are being carried out on the performance and design aspects of geosynthetic reinforced soil structure. Many countries have adopted their separate design principles of geosynthetic reinforced soil walls and steep slopes.

There is not record of geogrid reinforced soil construction in Nepal. But now, many suppliers of geogrids are interested to supply geogrid for the construction works. In this context, it is proposed to investigate the existing design principles of geosynthetic reinforced soil structures and formulate suitable design method which is appropriate for our topographic situation.

The design steps proposed in this work are based on the standard Jewel method of design of reinforced soil walls and slopes which considers all the required partial factors.

Case studies are carried out for seven different conditions with variable pore water pressure coefficients, angles of shearing resistance and wall heights, Geogrid reinforced retaining structures are found to be most economical among the considered walls. In addition to the economic viability, the geogrid reinforced soil walls have remarkable features like high seismic resistance, environment friendly, easy construction technology.

Thesis Title: TORSIONAL EFFECT IN STRUCTURAL CONCRETE BEAM

Submitted by: Jagadiswar Man Shrestha

Supervisor: Dr. Mohan Prasad Aryal

ABSTRACT:

Torsion is the moment acting on the plane of a member perpendicular to its longitudinal direction. Torsion occurs in monolithic concrete structures primarily, where the load acts at a distance from the longitudinal axis of the member. The examples of structural elements subjected to torsion are an end beam in a floor panel, a spandrel beam, a canopy, a helical staircase etc. Pure torsion exists rarely in practice. Mostly it occurs with other structural behavior such as flexure or shear or both. In the torsion dominant structures, it affects seriously in the behavior of element, because of drastic reduction in strength of beam under various combination of loading.

In order to consider the torsional effect in a beam, study has been carried out in this work for the torsion dominant element with torsion to flexure moment ratio (T/M) as I. The study is mainly based on experiment. This includes the development of fixing support and loading arm and loading arrangement of the system with universal testing machine (UTM) in order to test the beams.

The UTM with a loading capacity of 22.5 KM is computer interfaced from which the tensile and compressive force and corresponding, deflections data can be recorded.

The study has been carried out for beams with dimension 1300 mm x 125 mm x 200 mm (L x b x D). The total steel volume percentage (longitudinal and stirrup) in the beam varied from 0.94 to 1.99. There were five types of reinforcement arrangements. For each type of beams with various reinforcement arrangements, torque-twist (T-θ) relationship and respective curve equations have been developed. The effect of increment of reinforcement in torsional properties of RCC beams (i.e. torsional strength, toughness, rigidity, ductility) have been observed. Data also show that the torsional rigidity for the given reinforcement arrangements exhibit significant effect in post cracking than in precracking stages. Obtained experimental results are very close to the provisions made in Australian and Indian codes. Other codes in comparison to the present results overestimate the capacity of a torsion dominant RCC beam under combined loading.

Thesis Title: TWO DIMENSIONAL ELASTO-PLASTICS HARDENING MODEL FOR STRESS ANALYSIS

Submitted by: Kanhaiya Bhagat

Supervisor: Prof. Dr. Kozo Wakiyama

ABSTRACT:

The phenomenon of a material being able to withstand greater stress after plastic deformation is known as strain hardening or work hardening, in the sense that as stronger the material gets, the more it is strained or worked. Most of the engineering materials usually exhibit work hardening behavior.

Several constitutive models have been proposed by various authors to obtain stress-strain relation 1'or work hardening materials, and sound numerical algorithms have been developed to solve elastic-plastic structural problems. In the present work for the sake of mathematical simplicity, the simplest linear isotropic hardening model is adopted. Only the Tresca and von Mises laws, which closely approximate the metal behavior are considered. The finite element method is adopted to compute structural behavior, and the iterative solution scheme based on Newton-Raphson method is employed to solve basic equations relating force displacement characteristics of the structure.

Different solution algorithm options are included e.g. initial stiffness method, tangential stiffness method, and combined initial and tangential stiffness method.

Few examples are solved to verify the effectiveness of solution package developed, and the numerical results obtained are compared with the theoretical results.

Thesis Title: RESPONSE OF BARRAGES TO EARTHQUAKE GROUND MOTIONS INCLUDING HYDRODYNAMIC EFFECTS

Submitted by: Nirmal Shashi Gautam

Supervisor: Prof. P. N. Maskey

ABSTRACT:

Responses of barrages to earthquake ground motion are presented. The N-S component of Imperial Valley earthquake (El Centro, California, U.S.A.) of May 18, 1940 is chosen as the prescribed earthquake. Dynamic analyses are carried out on an assumed model pier of barrage. Plane-stress as well as 3-d models are used to model the barrage into finite elements. A case study is carried out. Bagmati irrigation project barrage is selected for this purpose. Dynamic analyses of Bagmati barrage pier to El Centro ground motions are performed. Only dynamic analyses due to earthquake excitations are carried out. Some static values are calculated only for the purpose of comparison with the calculated dynamic values. In the analyses, earthquake effects on the mass of the barrage and on incompressible reservoir are considered. Earthquake effects impart hydrodynamic pressures besides hydrostatic pressure on reservoir. The pressure is 180° out of phase to the ground acceleration and is considered to be equivalent to added mass to the barrage. The analyses are carried

out for no water in the reservoir, and also for various levels of water in it.

Thesis Title: STUDY OF VARIOUS STRUCTURAL SYSTEMS UNDER SEISMIC EXCITATION

Submitted by: Suhrid Kumar Sharma

Supervisor: Prof. P. N. Maskey

ABSTRACT:

The dynamic analysis of a twelve-story building with various structural systems was carried out. The structural systems basically comprise of frame, frame-shear wall, frame-coupled shear wall, eccentrically braced frame (EBF), concentrically braced frame (CBF), and hybrid type. Five variations in frame structure, four in frame-shear wall, two each in frame-coupled shear wall and hybrid type were investigated. The member dimensioning was based on the interstory drift index of 0.004 as the design criterion. The spectral pseudo-accelerations were generated by a computer program for the north-south component of the El Centro ground motion recorded during the Imperial Valley earthquake of May 18, 1940 and were used as input in the Response Spectrum analysis. The Time History analysis was also carried for the same ground motion.

The design based on interstory drift criterion generally results into the same levels of stiffness whatever may be the structural systems. The CBF is the most efficient system in terms of

concrete weight per unit area. However, the concentric bracing causes the structure to become very stiff and invites very high base shear and overturning moment. The best efficiency, in frame is achieved when the columns in the perimeter of the building with suitable connecting beams are designed to principally resist the lateral loads. Almost uniform interstory drift can be achieved through frame-shear wall interaction. Properly combined shear wall with braced frame is a very efficient system.

Thesis Title: REUSE OF LOCAL WASTE MATERIALS IN CEMENT CONCRETE

Submitted by: Bharat Mandal

Supervisor: Dr. Mohan Prasad Aryal

ABSTRACT:

In the past few decades, significant amount of the experimental work has been done to replace the cement with pozzolanic industrial by-products (fly ash, ground granulated blast furnace slag, condensed silica fume, rice husk ash etc.) in different part of the world.

This study gives an overview of the physical and chemical properties of some of the coal ashes and stone dust available in Nepal and deals with the properties of fresh and hardened cement concrete with these mineral admixtures. The properties of fresh concrete investigated include workability, normal consistency, setting time, and autogenous temperature rise and those of the hardened concrete include compressive and flexural strengths, modulus of elasticity. Durability to chloride and sulfate attack, water absorption and pore refinement characteristics, and microscopic study. In addition, the effects of different percentage of coal ash and stone dust on the properties of concrete at

different structural levels (paste, mortar & concrete) have also been carried-out.

Data indicate that the replacement of cement by coal ash as mineral admixture in cement concrete in the range of 20% to 30% of cement by weight gives nearly same strength in 14 days and almost 25% more strength in 28 days. In the case of replacement of cement with stone dust by 20%, compressive strength decreases slightly at the age of 28 days. The concrete replaced by 20% coal ash has been found to be more durable against acid and sulfate attack than concrete without ash. Similarly Use of such mineral admixture decreases the heat of hydration.

Thesis Title: FATIGUE EFFECT ON HIGHWAY CONCRETE BRIDGES IN NEPAL

Submitted by: Ganesh Bahadur Kadel

Supervisor: Dr. Mohan Prasad Aryal

ABSTRACT:

Fatigue is the progressive internal permanent structural damage due to repeated loading. Vehicular traffic on highway bridges causes repeated loading and fatigue effect occurs. Consideration of fatigue effect on structures has been made in some of the standards like AASHTO specifications, British Codes and others. The consideration is made by developing stress-cycles (S-N) curves due to fatigue design truck, which reflects the characteristics of their road vehicles. Indian Road Congress has not yet incorporated the fatigue effect in the design of bridges. The most affecting parameters in fatigue life of bridges are configuration of veil ides, traffic characteristics, load range and material properties of the structures. In order to reflect the actual behavior of road bridges in Nepal, data on traffic characteristics, vehicle types, their configurations and load ranges at 9 different road sectors of the country have been collected. The data have been analyzed and fatigue design truck has been calculated. The effect of vehicles and fatigue design truck have been calculated on bridges of span 25 m. 20 m and 15 m and compared to the

effect due to standard loadings. Damage assessment of bridges has been performed using existing relationships and life span has been calculated for 25 m. 20 m and 15 in span bridges using Miner's hypothesis.

Materials from five regions of the country have been collected, Experimental investigations have been carried out and S-N curves have been developed. Damage assessment and life-span prediction of road bridges at 9 different road sectors of the country have been carried out from experimental S-N curves and the results have been compared to the theoretical ones. It has been observed that (lie fatigue model trucks adopted as the design vehicles in different standards do not reflect the same effect to that of the actual fatigue model trucks which were obtained from the traffic composition at different road sectors in the Nepal. The physical properties of ingredients and concrete used for bridge construction at different parts of the country have been observer different. Life-span calculations of bridges from theoretical and experimental S-N curves have been observed different. From the study, it has been also observed that the life-span of bridges have been seriously affected by sonic of the vehicles in the traffic composition. For achievement of normal life-span of bridges, the fatigue effects of these vehicles have to be incorporated in design of bridges in Nepal. More researeh has been suggested to incorporate the fatigue effect in design for justification of results and cope with all possible ranges of loading and all types of span of bridges.

Thesis Title: **DYNAMIC RESPONSE ANALYSIS OF A CONTINUOUS BRIDGE SUBJECTED TO MULTIPLE SUPPORT EXCITATION**

Submitted by: **Jagat Kumar Shrestha**

Supervisor: **Mr. Prajwal Lal Pradhan**

ABSTRACT:

A computer programme is developed to compute earthquake behaviour of a bridge using uniform support excitation and multiple support excitations. The earthquake behaviour of a three span continuous box girder bridge subjected to uniform and multiple support excitation is investigated using the software developed. Small amplitude oscillations and linear-elastic material behaviour are assumed. Soil-structure interaction effects are discarded. The results are compared between uniform support excitation and multiple support excitation analysis. The modal contributions of some higher modes are larger than those estimated by the First few modes. Therefore, an analysis of a bridge should not be limited to for few first modes only. The model analysis shows that the modes should not be not less than 6 for this case.

Significant differences in dynamic responses are predicted for a bridge subjected to multiple support excitation and uniform

support excitation. The response of some degrees of freedom is maximum in non-uniform excitation analysis.

Thesis Title: WIND INDUCED VIBRATION OF ANTENNA TOWER

Submitted by: Madan Sharma

Supervisor: Prof P. N. Maskey

ABSTRACT:

Self standing tower is one of the popular means of supporting antennas for transmitting and receiving radio signals. These towers and antennas are acted upon by variable wind loads at different levels causing it to vibrate.

The safe and functional design of such structure is important in relation to the overall economy of signal transmitting system for quality transmission. It was realized that with the adoption of an exact method of analysis one would save a great amount of time, labor and material.

This thesis provides an analysis of the response of these towers to randomly varying time dependent wind and compares it against the previously adopted quasi-static method of analysis of these structures. The analysis duly considers the energy spectrum proposed by Emil Simiu. Analysis is performed considering a particular height of tower but with different base widths and antenna positions. The thesis presents both deterministic and

probabilistic method of analysis which could be utilized in the practical design of antenna towers.

Thesis Title: ANALYSIS OF BUILDING FRAME UNDER SEQUENTIAL LOADING

Submitted by: Rajendra Prasad Sharma

Supervisor: Mr. Prajjwal Pradhan

ABSTRACT:

This thesis paper deals with the effect of construction sequence in the analysis of building frames. Two computer programs are developed based on conventional and sequential loading concept. The validity of programs are checked by the help of standard conventional software. Analyzing 3 story, 6 story, 9 story, 12 story building frames by these two methods and comparison of responses indicates the importance of sequential loading analysis with clearly showing the deviation of sequential analysis results from the conventional one. Actual effect on design loads due to sequential loading is also studied, and effect due to support settlement and P -Delta effect is also discussed.

Thesis Title: LOW COST INFRASTRUCTURE DEVELOPMENT ON BHUTANESE REFUGE CONTEXT

Submitted by: Thag Bahadur Poudyel

Supervisor: Dr. R. N. Shrestha

ABSTRACT:

Site planning is necessary because the physical organization of a settlement can markedly affect the health and well being of a community. Site planning should take account of sanitation, water supply, roads, administrative and community services.

Bamboo has been used for refugee hut construction. In order to reduce the cost of bamboo hut construction, feasibility of different hut models have been entertained. Thatch and sandwich panels instead of local plastic sheets have been chosen for roofing materials.

Poor jointing and fixing techniques undermine the strength of bamboo structural members. Hence, various bamboo joints like use of tourniquets, fixing are ridges, fixing at an eaves junction and of use of cleats is introduced with suitable diagrams.

The VIP latrine has proven to be a cheap, successful technology, suitable for construction on a large scale in a short period of

time. In order to reduce the overall cost of latrine, single ring have been used instead of double ring. But, there is a problem of pit sinking with single ring latrines.

Drinking water is extracted from deep wall and distribution is done by gravity flow system with pipe network. When issuing materials for repair and maintenance, it is best to distribute per cut pieces rather than whole bamboo poles.

Graduation Year 1999

Thesis Title: AN INVESTIGATIVE STUDY OF THE STRUCTURAL SYSTEMSOF TEMPLES IN BHAKTAPUR (KATHMANDU VALLEY)

Submitted by: Binod Raj Chalise

Supervisor: Prof. Prem Path Maskey

ABSTRACT:

This thesis paper deals with the study of traditional Temple structures in Bhaktapur. The work was carried out in four parts. In the first part, historical as well as structural data collection works of all the major temples, in the second part, structural classification of temples, in the third part, laboratory experiments to find the stress capacities of masonry and in the final part, static as well as dynamic linear analysis with the three dimensional temple frame models were carried out in order to identify the vulnerable (in terms of maximum moments and stress) members during earthquake excitations.

Thesis Title: STUDY OF HOLLOW CIRCULAR COLUMN

Submitted by: Debendra Raj Dhungana

ABSTRACT:

Various studies are carried out for hollow circular column section to know the behavior of the column. The column sections are applied for different RCC framed structures to calculate different forces coming on them. These forces are compared with the forces obtained from solid circular section. Cases are studied for Interaction curves subjected to Axial load and Uni-axial bending moments. Shear capacity of frame columns with different spacing, Capacity of materials and strength. Resistance of frames to lateral forces and Ductility consideration and a comparative study has made between hollow as well as solid circular column.

Thesis Title: **USE OF STONE DUST PRODUCED FROM STONE CRUSHER AS A REPLACEMENT OF NATURAL SAND IN MORTAR AND CONCRETE**

Submitted by: **Prashanna Man Shrestha**

ABSTRACT:

In the past few decades, various studies with experiments has been done to use stone dust produced from store crusher and to use manufactured sand in place of natural sand in different parts of the world. The studies were concentrated in the places where natural sand of acceptable quality is not available easily.

This study gives an overview of physical and chemical properties of stone dust, available in Kathmandu Valley. The stone dust available at stone crusher is directly used to replace sand in cement mortar and concrete.

The various properties investigated on mortar and concrete at fresh and hardened state are normal consistency, Workability, Densities, Compressive and Flexural strength. Durability to chemical attack, Stress - Strain curve nature and Water absorption. The mortar and concrete specimens were prepared

with replacing sand by stone dust in different proportions (0, 20. 40, 60, 80 and 100%) and tested to investigate above properties.

Compressive and flexural strength is high on mortar with stone dust replacing sand and similar in the concrete with stone dust and sand. The stress-strain curves for concrete cubes and load-deflection curves for concrete and mortar beams are similar for both types of specimens. The durability against sulfate and acid attack is similar in both stone dust and sand concrete. The water absorption is slightly more in sand concrete than the stone dust concrete.

Thesis Title: BEHAVIOUR OF JOINT IN STEEL STRUCTURE

Submitted by: Sanjay Kumar Mull

Supervisor: Mr. Prajwal Lal Pradhan

ABSTRACT:

This thesis paper deals with the study of behaviour of joints in steel frame structures. A computer software programme is developed for 2-D frame analysis in which a special consideration of joint of connection behaviour is taken into account. The validity of software is checked with standard software. Frames with different types of joints are analyzed with developed software and responses are compared. Improved or economical joint is one which gives least lateral displacement.

Thesis Title: **STUDY ON THE EFFECT OF BRICK INFILLED WALLS IN REINFORCED CONCRETE FRAMES**

Submitted by: **Bimal Shrestha**

Supervisor: **Mr. Prajwal Lal Pradhan**

ABSTRACT:

This study is a small effort in the direction of preparing an analysis model to aid the development of the appropriate design provisions incorporating the effects on infill walls in the seismic design of masonry infilled RC frames. One of the basis objectives of the study is to analyze the different computer simulation models for the infilled frame and develop a simple appropriate effective model to find the responses of the brick infilled R.C.C. frames. The second objective is to use the appropriate model and compare the different responses in bare frame and brick infilled frame of multistoried buildings.

A total of four models with brick infilled namely equivalent frame approach diagonal strut approach, modified diagonal strut approach, frame shell approach and one bare frame model were analyzed in the study. The results of two frames, one bare frame model and the other brick infilled tested in the Kanpur (IIT) Laboratory were also used for comparison. The geometrical

properties of all the four models and the bare frame model taken for study are kept the same as of the frame tested experimentally in the Kanpur Laboratory.

In all the models, lateral load capacity of the frame was determined by increasing the lateral load till the failure of the frame due to sliding of shear or due to the flexural action. The analytical results of strength and stiffness were compared with the experimentally obtained data and the appropriate model selected for the analysis of multi-storeyed (9 storied taken) building frame as an example. The different responses obtained by the conventional analysis approach and the model analysis approach were studied in this 9-storied building frame. The response obtained in the bare frame is also compared. Diagonal Strut approach is found to be the effective model for the analysis of infill wall. Frame shell approach is suitable for the analysis of brick infill wall with openings in it. The effect due to P-delta is also studied but found to have very small effect on the frame considered.

Thesis Title: BASE ISOLATION OF HIGHWAY BRIDGES

Submitted by: Chandra Narayan Yadav

Supervisor: Prof. P. N. Maskey

ABSTRACT:

Base isolation of highway bridges with the use of lead rubber bearing is investigated Dynamic analysis of a typical three Span R.C.C. bridge is carried out. Bridge system is considered as a plane frame in the vertical plane passing through the center line of the bridge. Bearings are considered as frame elements. Only effects of dynamic load are considered. El Centro ground motion recorded during the Imperial Valley earthquake of May 18, 1940 are used as seismic input.

A computer programme is developed to handle material non-linearity. Due to use of lead rubber bearing. Due to memory problem non-linear time history analysis is carried for the single span bridge only.

With the use of lead rubber bearings internal forces in piers and abutments are significantly reduced. Hence lead rubber bearings can be used as an effective base isolation means to make highway bridges seismic resistant.

Thesis Title: **REINFORCEMENT EFFECT DUE TO TORSION IN STRUCTURAL CONCRETE BEAM**

Submitted by: **Nhuchhe Narayan Maharjan**

Supervisor: **Dr. Mohan Prasad Aryal**

ABSTRACT:

Torsion is the moment acting on the plane of a member perpendicular to its longitudinal axis. Torsion occurs in monolithic concrete construction primarily where load acts at a distance from the longitudinal axis of the structural member. An end beam in floor panel, a spandrel beam receiving load from one side, a canopy or a bus stand roof projecting from a monolithic beam on columns, peripheral beams surrounding a floor opening, or a helical staircase are all example of structural elements subjected to twisting moment. Reinforced concrete members in a structure may be subjected to axial forces, shear forces, bending moments, torque, or a combination of these effects.

For most design situations, bending moments and shear forces are considered primary effects, whereas torsion is regarded as secondary. Twisting moments occasionally cause excessive shearing stresses. As a result, serve cracking can develop well

beyond the allowable serviceability limits unless special torsional reinforcement is provided. Pure torsion exists rarely in practice. Mostly it occurs with bending, or shear, or both. In the torsion dominant structures, it affects seriously in the behavior of the reinforced concrete structures, due to the drastic reduction of the strength of beam under the various combination of loading.

In order to study the reinforcement effect in a beam, the study has been carried out for the torsion dominant element with torsion to flexure moment ratio (T/M) equal to 1. The study of present thesis work is mainly based on experiment. Rectangular beams with dimension 1300 mm x 125 mm x 180 mm (L x B x D) have been used for study.

Three types of reinforcement arrangement have been adopted. In the first group, the minimum percentage of compression steel (i.e. p_c = 0.5%) was kept and the percentage of tensile reinforcement was varied from 0.5 to 1.52%. In the second group, the percentage of compression (i.e. p_c = 0.79%) was kept constant and the percentage of tensile reinforcement was varied from 1.13 to 2.4% and in the third group, the percentage of tensile reinforcement (i.e. p_c = 1.52%) was constant but the percentage of compression reinforcement was varied fro 0.5 to 1.4%. For all groups the spacing of stirrups (s_v = 55 mm) was also kept constant. For each type of beams, the torque-twist (T-θ) relationship and its respective curve equation have been developed. The effects of reinforcement in torsional properties of reinforced concrete beams (i.e. torsional strength, torsional rigidity, toughness and ductility) have been observed. The experiment data show that the tensile reinforcement has significant effect in torsional rigidity in post-cracking than in pre-cracking stage but has less significant effect of compression reinforcement. The torsional strength increases with the increase of the tensile reinforcement, whereas the torsional strength decreases with the increase of the compression steel. The tensile reinforcement has significant effect of toughness in RCC beam with constant compression reinforcement as well as stirrups. The toughness increases linearly with the increase of the tensile reinforcement. The toughness does not so increase when the percentage of compression steel increases but keeping the percentage of compression as well as stirrups constant (i.e. the toughness value is more or less same).

The results obtained from the experiment are very close to the provisions made in Indian and Australian codes. In comparison to the present results, other codes overestimate the capacity of a torsional dominant RCC beam under combined loading.

Thesis Title: STUDY OF SEMI-RIGID JOINED R.C.C. STRUCTURE

Submitted by: Ranjan Manandhar

Supervisor: Mr. Prajjwal Lal Pradhan

ABSTRACT:

This thesis paper deals with the effect of consideration of the rigid beam-column joint by considering it joint on basis of analysis of building frames. One computer programme is developed keeping the rotational spring at the joint and validity of program is checked by standard software MICROFEA, 3 STORIED, 6 STORIED. 9 STORIED and 12 STORIED building frames were analyzed by developed software to see the variation of the result and responses of the semi-rigid jointed structure due to moment resisting rigid jointed structure. Comparison indicates the importance of considering the joints as semi-rigid, because the structure assumed to be safe is very week in joint and falls from the joint however the members' structures is safely designed.

Thesis Title: USE OF SUPERPLASTICIZERS FOR HIGH STRENGTH CONCRETE IN NEPAL

Submitted by: Saroj Bhattarai

Supervisor: Dr. Mohan Prasad Aryal

ABSTRACT:

Production or high strength concrete (HSC) is one of the major issues to meet the newly emerging demands in the construction industry in Nepal. The need of good workability has been one of the main obstacle in production of HSC is this country since most of the concrete works are done manually. This study focuses on the production of HSC using local materials and the available superplasticizers in Nepalese conditions. Crushed stone and natural river gravel from four different construction sites around the country were used without any modification in the grading. Seven types of superplasticizers were tested and finally one was selected for the detailed studies.

The results show that it is possibly to produce HSC with materials available in Nepal. It was possible to decrease the water/cement (w/c) ratio of the mix down to 0.32 using superplasticizer, maintaining an average slump of 135 - 165 mm. the 28 days characteristic strength thus gained was up to 58 MPa. The average reduction in water demand by use of

superplasticizer was 21 percent. The superplasticizer was found to be more effective in mixes with river gravel than with crushed stone aggregate, both in terms of workability and strength. It was also observed that the strength of superplasticized concrete is more than the strength of concrete without superplasticizer with the same w/c ratio, the performance of the superplasticized concrete is also found to be better against chemical attack. This study also provides the basis for the possibilities of producing high performance concrete with careful selection and grading of aggregates and by combined use of mineral admixtures with superplasticizers.

Graduation Year 2000

Thesis Title: SEISMIC RESPONSE OF BUILDING FRAMES WITH VERTICAL STRUCTURAL IRREGULARITIES IN MASS AND STIFFNESS

Submitted by: Ananta Acharya

Supervisor: Dr. Rajan Suwal

ABSTRACT:

Earthquake design codes require different methods of analysis for regular and irregular structures, but it is only recently that some codes have included some specific criteria that define irregular structures. The prevailing and most popular code of practice for Earthquake Resistant Design of Structures in the region IS 1893-1984 has not yet included any such criteria. In this paper the effect of introduction of structural irregularly, in vertical plane in the seismic response is evaluated by both the methods as specified in IS 1893-1984 and the difference (error) is sought. The irregularities considered are in mass and stiffness. The structures studied are building frames with 5, 10 and 15 stories each of two types with different column sizes giving two different fundamental time periods for each type. The irregularity in mass is introduced ranging from 0.5 to 2.0 at different floor

levels one at a time. The irregularity in stiffness is considered only in the 1st story by lowering the stiffness of it from 1 to 0.6. Conclusions are derived from the effects of irregularities on base shear, axial force and increase in drift.

Thesis Title: **EFFECT OF GRADE BEAM ON FRAMED STRUCTURE CONSIDERING SOIL INTERACTION**

Submitted by: **Dileep Kumar Pokharel**

Supervisor: **Prof. Dr. R. K. Poudel and P. L. Pradhan**

ABSTRACT:

Guide beam is essentially provided in most of the reinforced concrete framed structures but its contribution is not accounted in the conventional method of structural analysis. Soil-structure interaction should be considered in order to include the contribution of grade beam in the analysis. Possible modification in the conventional analysis is desired so that general practioners and engineers can perform even conventional analysis of structures with the same effect. With this objective in this work, a one bay and one storey portal frame with a grade beam and isolated footings has been analyzed for static lateral loads using the conventional model, soil-structure interaction model and spring model (modified conventional model). The height of the frame is kept constant whereas the width is varied. The depth of the grade beam is also varied. Soil properties for only one type of soil (dense sand) have been adopted. Contribution of grade beam in the frame is studied including the effect of soil interaction. Geometric nonlinear analysis has been done for all three types of

models using incremental load method. Only two response parameters namely the lateral displacement of the frame and moments at the column bases has been considered. Modification in the conventional model has been recommended introducing rotational springs at the column bases, which will incorporate the effect of grade beam as well as soil interaction. A relation to compute the stiffness values of the springs in terms of width of the frame and depth of the grade beam has been derived. The recommended spring models are verified comparing the response values to that of the corresponding soil-structure interaction models.

Thesis Title: SEISMIC HAZARD ANALYSIS FOR KIRTIPUR AREA

Submitted by: Kulendra Nath Subedi

ABSTRACT:

Probabilistic Seismic Hazard Analysis of Kirtipur area is confined to two sites namely, Kirtipur (top of the hillock) and Tribhuvan University (TU) campus area. This is intended to find the seismic hazard at rock outcrop and soil sites respectively. Geological fault sources are taken as active seismic lineal sources lying in the vicinity, within the 150 x 150 km2 area of Kirtipur city. The identification and characterisation of the seismic sources are based on the data from the report - 'Seismic Hazard Mapping and Seismic Risk Assessment for Nepal, 1994' prepared as a part of National building Code Project (HABITAT). The spatial and size uncertainties of the seismic sources are carried out, and probability distribution of source-to-site distance and magnitudes are determined. The earthquake recurrence law proposed by Gutenberg-Richter is adopted.

Various published attenuation laws in the form of empirical relations are considered and tested for the suitability for the region. The amplification of bedrock motion at ground surface due to the soil sediment is evaluated using SHAKE computer

program developed by Schnabel 1979, California. An E1 Centro 1940 acceleration time history is taken as input motion at bedrock for the purpose.

The probabilistic seismic hazard analysis is carried out using conditional probability theory. The curves of mean annual rate of exceedence a against Peak Ground Acceleration (PGA) as the intensity for each sources are drawn. Poisson's model is used for the hazard curves of probability of exceedence for different return periods in years against the Peak Ground Acceleration (PGAs). Response spectra for acceleration for two sites having peak ground acceleration (PGAs) of 10% probability of exceedence within 5 and 50 years period are worked out and presented.

Thesis Title: EFFECT OF CURTAILMENT OF SHEAR WALLS AT DIFFERENT LEVELS ON THE SEISMIC RESISTANCE OF MULTI STORY BUILDING

Submitted by: Malati Singh

Supervisor: Prof P. N. Maskey

ABSTRACT:

Tall building is one of the significant factors of urban development. Proper planning prior to design and implementation leads to economical construction of the structure. Curtailment of Shear Walls at certain level in the case of Shear wall structure can minimize the cost of construction. The study is intended to determine the level of curtailment that safely withstands the building in terms of strength as well as serviceability.

The study is carried out for a twelve-story frame-wall building subjected to seismic excitation. Seismic loading applied is that of north-south component of ground motion recorded at a site in El Centro during the Imperial Valley earthquake of May 18, 1940. Various proportion of walls and frame are carried out for the same plan of the building, under drift ratio limit of 0.004, the shear wall of a twelve-story building can be reduced to tenth

level. In multistory buildings designed for a similar purpose and of the same material and height, the efficiency of the structures can be compared roughly by their volume per unit area. In terms of concrete volume, the percentage reduction of gross concrete volume of curtailed wall structure with respect to the "full-wall" structure is 8.77& for the optimum structure.

Thesis Title: **CONTRIBUTIONS OF FLOOR SLAB IN REINFORCED CONCRETE FRAME STRUCTURE**

Submitted by: **Prachand Man Pradhan**

Supervisor: **Prajwal Lal Pradhan**

ABSTRACT:

This thesis deals with the study of the contributions of floor slab in reinforced concrete frame structures. In current practice, the conventional method of structural analysis ignores the contribution of floor slab. Therefore, this study was done to determine the contributions of floor slab in terms of deflections and moments when a structure experiences different loading conditions.

This study was done with one by one by three dimensional, symmetrically planned, one storey, three storey, five storey, seven storey and ten storey structures. Linear analyses using SAP90 computer program were performed for three different types of models with and without slab considerations for different loading conditions. Among the models, one was provided with an L-beam flange as per the Indian Standard Code. IS: 456-1978. The floor was not assumed as rigid diaphragm in the analyses works.

It was observed that the floor slab also contributes in resisting the horizontal displacements of a structure. In this regard, it was found from the frame analysis that if the presence of slab is also considered, then it contributes in such a way that the floor level horizontal displacement due to horizontal loading gets reduced by about 36% when compared to analysis without slab's participation. Similarly, the slab also, contributes in resisting, the deflection of beams by more than 36%. The rotational displacement of the floor level due to torsional moment, also gets reduced by more that 25% if the slab's participation is considered in the analysis. It was found that the flange beam width from the Indian Standard Code, I.S. 456-1978, is sufficient to be adopted in the frame analysis to obtain nearly accurate results. The Codal provision regarding L-beam flange width was found to be very much accurate in terms of torsional analysis.

Thesis Title: EFFECTIVENESS OF BASE ISOLATION IN MASONRY BUILDING

Submitted by: Jishnu K. Subedi

Supervisor: Prof. Prem N. Maskey

ABSTRACT:

The performance of unreinforced masonry buildings during earthquake has long been recognized as not very encouraging. The resistance of unreinforced brick masonry to earthquake induced load is governed by its limited tensile and shear strengths, connection between the walls, and workmanship. Hence to make it an earthquake resistant structure has numerous limitations. One of the most promising methods to make structures, including masonry buildings, safe from devastating effects of earthquake is to introduce base isolation device at a suitable location in the structure. By providing base isolation, the intensity of earthquake passing to a structure can be reduced significantly, so that, the structure experiences reduced forces.

A mathematical model is presented and a program in 'C' is developed to determine the response of a rigid body, isolated from the ground acceleration by providing a sliding layer. The response characteristic is presented for El Centro 1940 earthquake (N-S) and for Harmonic excitation. Another

mathematical model is presented for analysis of Multi Degree of Freedom of structure. The model consists of a rigid plastic link to represent the friction type of isolation in the foundation raft. A computer program in 'C' is developed to calculate response of SDOF structure with rigid plastic link.

Two different types of simple structures, one two-dimensional portal frame and another three-dimensional structure are analyzed with sliding type of isolation system in foundation raft. The analysis is carried out with different parameters. El Centro (1940) and Kobe (1985) earthquakes are used for the analysis purpose.

A typical pagoda style of Nepalese temple, constructed basically with brick masonry and timber is considered for base isolation analysis. The temple is analyzed both as the conventional structure and as a base isolated structure from the ground motion of earthquakes in the form of time history.

The response of structures is reduced significantly with introduction of sliding system in the base. The forces in different members are reduced significantly. However, there is slight increase in relative to ground displacement of the structure and residual displacement. The increase in residual displacement is observed with decrease in coefficient of friction. The response of structure varies with the rate of mass of structure to the ratio of foundation raft. For higher ratio the acceleration response spectrum is independent of frequency. Evidently, sliding type of isolation can be used effectively within a high range of frequency.

Thesis Title: OPTIMAL LOCATION OF SHEAR WALL IN FRAMED STRUCTURE

Submitted by: Bishnu Om Bade

Supervisor: P. L. Pradhan

ABSTRACT:

Population is increasing at an alarming rate everywhere, which needs housing and other infrastructure facilities. At the same time, multistory structures are a necessity particularly in city centers where land values are high. And now a days most of the slender residential buildings are being haphazardly constructed.

Therefore, one should develop a structural system such as introduction of shear wall, which will satisfy the structural criteria i.e. adequate lateral stiffness, an adequate reserve of strength against failure and an efficient performance during the service life of the building.

However, it is important in shear wall structure to try to plan the wall layout in such a way that the structure will exhibit minimum response during earthquake. And in order to get the optimal location of shear wall in horizontal plan, the following studies are made:

- Shear walls are placed symmetrically at different locations in the same building plan.
- Linear dynamic analyses of torsionally uncoupled wall-frame structures subjected to ground acceleration are made, assuming the floor as rigid diaphragm.
- The study considers displacement, base shear and base moment assuming a structure that is uniform through its height.
- Results obtained from analyses for different cases are compared and finally optimal location of shear wall is found out considering the responses.

Thesis Title: STRENGTH AND PERFORMANCE OF CONCRETE WITH VARIOUS TYPES OF AGGREGATE

Submitted by: Jagdish Chaudhary

Supervisor: Dr. Mohan Prasad Aryal

ABSTRACT:

Aggregate is naturally available material in Nepal. People in construction industries prefer crushed aggregate but processing is expensive. Pebbles and gravels of required size is widely available in most of the rivers and processing is less expensive. Studies on quality of natural aggregate are limited on geological parameters and some engineering parameters. Therefore, study on strength and performance of concrete with various tapes types of coarse aggregate available in various resources all over Nepal is one of the major issues to meet the newly demands of coarse aggregate in construction industries in Nepal. Crushed stone and Natural River gravel each from two different sources were used without any modification in grading.

The compressive and tensile strengths of concrete for various grades (M10 to M50) have been observed to be about 10 percent higher in crushed aggregates compared to river gravels. The

concretes both with crushed aggregates and river gravels have very good strengths with early high strengths.

Superplasticizers, commercially available in the market are more suitable for crushed aggregates but more study is needed in the aspect of compatibility with the available cement. This study also provides the basis for the possibilities of producing high performance concrete with careful selection and grading of aggregates (crushed aggregate and river gravels) and by combined use of mineral admixtures with superplasticizers.

Acid environment has a more effect in decreasing the strength of concrete with round aggregates compared to the concrete with crushed aggregates. But the same parameters seem to be opposite in the case of sulfate attack with in the range of our study.

The round aggregate, usually river gravel, available in Nepal has great compressive and wearing strengths. They produce concretes of great density and high compressing strength and can be used for the making of concrete economically.

Thesis Title: **DETERMINATION OF PHYSICAL AND MECHANICAL PROPERTIES OF TRADITIONAL ENGINEERING MATERIAL (BRICKS AND TILES)**

Submitted by: **Madhukar Rana**

Supervisor: **Dr. Rajan Suwal**

ABSTRACT:

Bricks and tiles are the mostly used engineering, material. For the thesis work five varieties of bricks and two varieties of tiles were collected from different sites and brick factories to find out their physical and mechanical properties. Different types of experiments, based on related IS codes, were performed on several of samples of bricks and tiles. Bricks and tiles were also tested to find out compressive strength in the form of cubes of size of their thickness.

Old facing brick was found to have highest value of compressive strength among the five varieties of bricks and Mahabir local brick seemed to be the weakest in compression. But in the form of cubes, Harisiddhi Chinese brick possessed highest compressive strength and Mahabir local brick was again found to be the weakest in compression. New facing brick was found to be the strongest in flexural strength with the highest value of

Young's modulus of elasticity and Mahabir local brick was the weakest also in flexural strength with lowest value of Young's modulus of elasticity.

New facing brick was found to have highest percentage of water absorption, by weight with the lowest dry density of 1.46gm/cm3 and old facing brick had the least percentage of water absorption, by weight. Harisiddhi Chinese brick possessed highest value of dry density of 1.78 gm/cm3.

Old tile was stronger than new tile in both compression and flexure with higher value of Young's modulus of elasticity. New tile absorbed more water, percent by weight than old tile. The old tile was denser than new tile. It is suggested that the values of flexural strength and E be verified in the further work.

Thesis Title: BRIDGE LOADINGS OF DIFFERENT COUNTRIES AND IN THE CONTEXT OF NEPAL

Submitted by: Mukti Gautam

Supervisor: Dr. Mohan Prasad Aryal

ABSTRACT:

There are different highway bridge-loading standards used in different countries. The highway bridge loadings should represent the traffics that might pass over the bridge during the lifetime of bridge. In this thesis a comparative study of the nine loading standards of different countries is carried out and the heavy, medium and lightest loading is find out for the case of single lane and double lane bridge.

The bridges of Nepal have been designed mainly on five different countries loading standards. Even in a single East-West highway different bridges are found designed on different loading standards. It seems there is an illusion even among engineers and concern authority of Nepal, that all the loading standards are equivalent. But in fact these loading standards are not equivalent and the maximum bending moment and shear force obtained from these loadings differ by about 2 times. This is tried to show in this thesis.

The T-beams of bridges of span 15, 20, 25 and 30 m for single lane and double lane bridges are designed on different five loading standards adopting the load factor, factor of safety and other provisions specified in respective codes and specifications. The relative capacity of bridges (with respect to capacity of bridges designed on AASHTO loading HS20-44) is then compared. From the comparison of relative capacity of bridges in Nepal, it is found that the bridges designed on 1RC loading (class A & AA) have highest capacity (about 1.6 times than that of bridges designed on AASHTO loading HS20-44). Although the live load bending moments (with impact) from Russian loading is greater than that of AASHTO loading, the capacity of bridges designed on Russian loading have found less capacity (about 0.9 times) than that of bridges designed on AASHTO loading. Here load factors and safety factors designated in respective codes have influenced on the capacity of bridges.

Traffic growth rate, traffic composition and traffic characteristic of Nepal is found out by processing and analyzing traffic survey data. The damaging effect (fatigue) of bridges, designed on different loading, due to traffic at different nine sections of road network is calculated. The most damaging truck is identified. The gross weight and configuration of fatigue design truck of

Nepal is calculated to represent the damaging effect of all traffic in distribution.

The bending moment from the maximum loaded truck is compared with the moment from standard loadings and loading standard closest to traffic of Nepal is identified.

Thesis Title: SEISMIC CAPACITY EVALUATION OF A HISTORIC TEMPLE IN KATHMANDU

Submitted by: Vishwa Prakash Amatya

Supervisor: Prof. P. N. Maskey

ABSTRACT:

This thesis paper is the study of a historic temple in Kathmandu under earthquake excitation. For the purpose of the study, the temple was modeled three dimensionally with different structural elements and the different behaviour of the temple.

In total two types of elements for the brick masonry were chosen viz. shell element and solid element. The floor diaphragm was modeled in two ways: flexible and rigid in its' plane.

Dynamic linear analyses were performed. Time History analysis and Response Spectra Analyses were performed to study the behaviors of the temple under earthquake excitation. Imperial Valley earthquake of May, 1940 was chosen as ground acceleration. Vulnerable parts of the temple were determined during earthquake excitation.

Graduation Year 2001

Thesis Title: **SEISMIC CAPACITY EVALUATION OF MULTI-TIRED TEMPLES OF NEPAL**

Submitted by: **Bijaya Jaishi**

Supervisor: **Prof. Prem Nath Maskey**

ABSTRACT:

The researeh is carried out to evaluate the seismic capacity of selected multi-tiered temples of Nepal for future earthquakes. Suitable modeling was developed and analyzed using solid and frame element in SAP90 software- Ten temples of different types were modeled and analyzed. Analysis was performed using Seismic coefficient method as recommended by IS 1893-1984. To achieve a more realistic result, 3-D dynamic analysis was performed separately using response spectrum in IS 1S93-I984 and EL Centre Earthquake, 1940. Results show that masonry temples in Nepal are more rigid having fundamental time period less than 0.25 seconds. The most crucial parts of Nepalese temples are the piers between openings at base level. Most of the failure modes are associated with tensile stress.

Thesis Title: **SEISMIC STRENGTH EVALUATION AND RETROFITTING OF EXISTING NON-ENGINEERED FRAMED STRUCTURED BUILDINGS WITHIN KATHMANDU MUNICIPALITY**

Submitted by: Deepak Manandhar

ABSTRACT:

Most of the buildings built for dwelling purpose within Kathmandu Municipality are constructed with little or no consideration for the forces generated on structure during an earthquake. As such, these buildings are built without following any guideline laid down by the Codes, More important, because of Kathmandu being situated in a highly seismic prone area, these buildings are not expected to respond to such an eventuality without being damaged or collapsed. The evaluation of strength of such non-engineered, RCC framed buildings is necessary to determine the vulnerability of such buildings under seismic loading.

Four sample buildings were chosen for the purpose of .strength evaluation. These four buildings were chosen after the careful analysis of record available with Kathmandu Municipality for the last four years based on the building permit given for the

construction of buildings. Of the four buildings, two are located within the core area of Kathmandu Municipality and the other two are located in the vicinity of the core urea.

All the lour buildings were analyzed for Dead Load, appropriate Live Load and Earthquake Loud as recommended by IS 1893:1994 Criteria for Earthquake Resistant Design of Structure to find out the response of the structure. The capacities of various members were calculated based on IS 456-1998. Code of Practice for Plain and Reinforced Concrete and on the actual size of members and reinforcement provided during the construction phase.

The study reveals that most of the members of the structure have demand forces which are higher than the capacity of the members, thus making the existing building highly vulnerable during the earthquake. The study also reveals that the existing building can be made safe by taking various appropriate measures like providing X-bracings etc.

Thesis Title: PRODUCTION OF HIGH PERFORMANCE CONCRETE IN NEPAL

Submitted by: Ram Prasad Pathak

Supervisor: Dr. Mohan Prasad Aryal and Dr. M. P. Singh

ABSTRACT:

High performance concrete (HPC) is the latest catch phrase in concrete. It has replaced the high strength concrete cry of the 80's boom. High performance concrete must have the high strength, high workability & high durability compare lo normal and high \ strength concrete. Production of high performance concrete (HPC) is one of the major-issues to meet the newly emerging demands in the construction industry in Nepal, where the strength of concrete in majority of cases is limited lo 25 to 30 MPa.

This study focuses on the production of HPC in Nepalese conditions using local materials, mineral admixtures (industrial by-product) and the available superplasticizers. Crushed stone and natural-river sand from three construction sites around the country were used for study without any modification in the grading. Coal ash as raw material was collected from two brick & tiles factories and prepared for experimental works. The physical & chemical properties of coal

ash were tested and found within the permissible limits as compared lo various standards. Ten types of superplasticizers were tested on different parameters at different structural levels and three of them were found satisfactory for this purpose and out of them only one type was selected for detail studies with the adopted local materials.

Data of the study show that the maximum water reduction capacities of the studied admixtures are in the range of 30, 30, and 4.S percent in paste, mortar and concrete levels respectively. The effect in strength is in the range of 10 percent when the initial curing temperature was 8 ± 2ºC. However, the increment has been observed up to 90 percent in some cases when the initial curing temperature was 28 ± 2ºC.

The optimum dosage of local mineral admixture is found to be in the range of 25 to 35 percent by weight of cement. Its effect is clearly observed at later age. The strength of concrete obtained in the lab with chemical and local mineral admixtures are in the range of 55, 70 MPa at the age of 28 and 91 days respectively.

Test data on chemical attack and sorptivity also show that the concrete with adopted chemical and local mineral admixtures are better than without these admixtures.

Based on the present study on physical and mechanical properties of concrete constituents, properties of chemical admixture available in the market, physical and chemical properties of local mineral admixtures and ultimately the physical properties as well as the strength and durability of concrete as an end product, it has been clearly observed the possibility of producing HPC with the local materials in the Nepalese context. With controlled conditions within the capacity of the prevailing construction activities, the strength of concrete with superplasticizers and local mineral admixture at 91 days can reach up to 80 MPa.

Thesis Title: **EFFECTS OF SECONDARY STRESSES ON CONCRETE PAVEMENTS IN NEPAL**

Submitted by: **Ganesh Prasad Poudel**

Supervisor: **Dr. Mohan Prasad Aryal**

ABSTRACT:

The researeh presents an overview of the climatic conditions and effects of secondary stresses in concrete pavements in Nepal. Comprehension of climatic conditions, quantitative evaluation of secondary stress, identification of grade of concrete for pavements and zoning of places are foremost aspects of the thesis. Temperature and relative humidity variations have been recognized as major environmental factors for the development of secondary Stress. Eighty geographical locations are considered to reflect the climatic condition of Nepal. Representative climatic figures reveal wide variations of the temperature and relative humidity in many places. Obtained relation, based on the available data shows soil temperature being 94.4 percent of daily mean temperature. The relation is extended to obtain temperature differentials in pavements. Relative humidity has been adopted in terms of equivalent temperature.

Adopted size of pavement for stress calculation is 4.5 m x 3.5 m rectangular slab, with 15 cm, 20 cm, 25 cm and 30 cm thickness. Effects of creep and fatigue in concrete pavement have been renowned. Presented stresses are based on modulus of elasticity of M25 grade concrete. Stress modification factors for other grade concrete have been suggested. Phase difference between the ambient temperature and relative humidity has been recognized. Their net effects are found to be subtractive in the development of secondary stress. Two extreme climatic conditions in a day are under consideration, IRC class. A wheel loading has been adopted to reflect the vehicle load. Quantitative evaluation of secondary stress is made for each .place. Concept of finite element has been acknowledged for stress calculation, using SAP90 computer program. Calculations show, in general, effect of secondary stress is 75 percent and that of applied load is 25 percent. The nature of stresses is found to be cyclic.

Tensile strength of concrete under the action of axial as well as bending governs the grade of concrete. Based on derived tensile strength and calculated stresses, minimum grade of concrete has been identified. Zoning of places has been made in very severe, severe, moderate and mild climatic exposure conditions.

Thesis Title: **REINFORCED EARTH STRUCTURES WITH GEO-TEXTILES FOR SLOPE STABILIZATION**

Submitted by: **Purba Kumar Rai**

Supervisor: **Dr. Mohan Prasad Aryal and R. K. Poudel**

ABSTRACT:

Application of Geosynthetic (Geo-textiles, Geo-grids, Geo-membranes etc) has significantly increased over the last few decades both in developed as well as developing countries. Use of soil reinforced wall as a modern earth retention system has proved to be a feasible and economical solutions all over the word.

The governing parameters in the design of soil reinforced structures are soil strength in the embankment, tensile strength of the reinforcement and the interaction between soil and reinforcement.

A design procedure for geo-textile reinforced walls which are subjected to uniform surcharge loads is presented. The design steps followed in this work considers all the required partial factors and is based on the standard Jewell method of design of reinforced soil walls and slopes.

In addition to economic and technical benefit, because of their flexibility to undergo large deformation, Geotextile-reinforced walls have the potential to sustain large dynamic impact.

Thesis Title: **FAILURE MECHANISM OF JOINTS IN RCC FRAME STRUCTURE**

Submitted by: **Sunita Shrestha**

Supervisor: **Prajwal Lal Pradhan**

ABSTRACT:

This thesis paper deals with the study of the failure mechanism of joints in RCC framed structures. The most common practice of the frame analysis is to assume the beam-column joint as a material point and the actual deformation in the joint cannot be visualized in the analysis. Actually different changes take place in the joint during the application of the load. The study was done to find out the strength of the interior and exterior beam-column joints, contribution of horizontal stirrups and the anchorage length of the bars in the joint, effect of axial load in columns in the stresses, effect of concrete strength in the stresses and deflection at the joints and to develop a crack pattern when a structure experiences the application of the lateral load.

Linear analysis was performed for twelve different types of interior and exterior beam-column joint models (i) with lateral reinforcement and anchorage length of lop and bottom bar beyond the depth of the beam and (ii) without the lateral reinforcement and anchorage length up to the end of the beam

depth (iii) with axial load (iv) without axial load in column (v) with concrete strength M20 (vi) with concrete strength M25. And anchorage length is for exterior beam-column joint only.

The study has shown that the lateral reinforcement in the joint causes significant resistance in the compression and tension stresses, the strength of specimens subjected to couple forces in the interior joint is less than the exterior joint subjected to uni-directional loading. And also from the experiment it was found that the stress values in the two diagonal directions were in tension, and their resultants were relatively close to each other. It is also found that the axial load also affects the stresses in the joint and the concrete strength has significant effect in reducing the displacement and stresses in the structure.

Thesis Title: **SOIL AMPLIFICATION FACTOR FOR KATHMANDU VALLEY**

Submitted by: **Ramesh Rajbhandari**

Supervisor: **Prof. Dr. Ram Krishna Poudel and Prof. Prem Nath Maskey**

ABSTRACT:

The amplification of the bedrock motion at the ground surface due to soil sediment in one dimension is evaluated using the EERA, computer program for equivalent linear earthquake site response analysis of layered soil deposits. The program was developed by J.P.Bardet, K. Ichii, and C.H- Lm, February 2000, University of southern California.

Sin curve of equation a × sin(ωt), acceleration time history are taken as input motion at the bedrock for the purpose of finding out the amplification. In the input motion equation, the amplitude (ω) is taken as unity and the frequency (ω) varies from 0.01 to 3.01 rad/sec with the interval 0.10 rad/sec.

The sample analysis for different shear wave velocity of bedrock, varying the amplitude of sine wave from0.igto0.4g and for individual soil deposits is carried out.

Various published empirical equations are considered to determine the properties of soil deposits. The amplification factor for the soil deposit at different location of Kathmandu .valley (ratio of PGA on the surface to the PGA on bed rock) is worked out and (he contour of the amplification factor of the valley is drawn with contour interval of 0.10 using the computer program SW_DTM. The cross section at different alignment having densely populated area of Kathmandu valley for the amplification factor is worked out and presented.

Graduation Year 2002

Thesis Title: **STRENGTH EVALUATION AND SEISMIC RETROFITTING OF RCC COLUMNS**

Submitted by: **Chandeshwar Prasad Gupta**

Supervisor: **Mr. Prajwal Lal Pradhan**

ABSTRACT:

The highway is most important mode of transportation infrastructure facility used in our country. To cross the natural streams we are forced to construct bridges that requires enormous amount of resources. However the most vulnerable elements in the highway system appear to be bridges sustaining damage to substructures and foundations and in some cases being completely destroyed. Since our nation is within seismic zone we could not undermine the roads and bridges threatened or destroyed by natural hazardous like earthquake and so on. To select such bridges an extensive survey has been conducted and ring road of Kathmandu valley has selected. These bridges are constructed on 1975 with the grant of Government of China. The design work of road as well as bridges was carried out jointly by Chinese engineers. To minimize the seismic hazard extensive researeh has been conducted to identify the strength of existing bridges element that would mitigate the effects of such hazards.

Specifically this effort tries to determine retrofitting measures of RCC columns of the Highway Bridges to minimize the loss of property and infrastructure.

At preliminary stage, a field survey ha been conducted to collect the shape, size, nondestructive testing etc. data required to model the structure. Schmidt Hammer test results shows the characteristic strength of concrete with 95% confidence level as 19, 65, 54 and 68 N/mm^2 for pile, pile-cap, pier and pier-beam respectively.

The load considered moving loads for class A- Train of loads and Footpath Loads as per IRC: 6-1966. The load transferred to the substructure such as piers, abutments are selected as per IRC: 78-1983.

Every effort is taken to create the model and its study so as to represent the real structural behavior of RCC Bridge Columns of Ring road at Kathmandu city. The model of pile, pile-cap, pier and pier beam are prepared as per actual size and shape with actual characteristic strength of concrete based on the commonly used reinforcement. The models are of Dhobi Khola and Manohara Bridges are considered in researeh. The models are designed for conventional gravity load, live loads & Earthquake forces and checked for pushover analysis using SAP-2000 nonlinear.

Thesis Title: **SEISMIC HAZARD ANALYSIS FOR JANAKPUR AREA**

Submitted by: **Daroga Prasad**

Supervisor: **Mr. Prajwal Lal Pradhan**

ABSTRACT:

Janakpur is a terai town in Nepal which is situated at a distance of 390 KM in South-West of Kathmandu. It falls under gangetic zone having silty and sandy clay to some extent. Observing the gravity of situation created due to past earthquakes (1934 & 1988 AD), it indicates that Janakpur and its vicinity areas have high seismicity. So I have selected this area for hazard analysis.

Probabilistic Seismic Hazard analysis of Janakpur area is done by dividing the whole assigned area into four areas/part. The whole area assigned for analysis is about 841 km2 located South of Mahendra Highway in Dhanusa district. Six geological fault sources are taken as active seismic point sources lying in the vicinity of Janakpur within the 275 X 66 km2. The earthquake recurrence law proposed by Gutenberg-Richter is adopted. A suitable attenuation law published by Joyner & Boore (1981) is used to compute the Peak Ground Acceleration for different value of magnitude, M.

The amplification of bedrock motion at ground surface due to layered soil sediment is evaluated using a Computer Program EERA (Equivalent-linear Earthquake site Response Analysis) developed by J.P.Bardet, K. Ichii and C.H.Lin 1998, California.

The probabilistic seismic hazard analysis is carried out using conditional probability theory. The hazard curves in terms of probability of exceedence against Peak Ground Acceleration as the intensity for each is drawn. Seismicity of the areas is written in mathematical form as follow:

A4>A3>A2>A1.

Thesis Title: **RELIABILITY ANALYSIS OF A R.C.C. FRAMED BUILDING**

Submitted by: **Hari Ram Parajuli**

Supervisor: **Mr. Prof. Dr. P. N. Maskey**

ABSTRACT:

Kathmandu valley lies in a seismically vulnerable region due to its proximity to numerous active faults in its vicinity. Important buildings for general public service like hospitals shall be reliable to continue their services even during and after disaster like the occurrences of earthquakes. In this regard, investigating the vulnerability of such structures, basically based on reinforced concrete frame structure is required. With this view a systematic study on the probabilistic risk analysis of such buildings in Kathmandu valley becomes important.

The present work consists of two major parts. The first part deals with study on the seismic input applicable to the region. Seismic hazard curves and response spectra have been obtained in a probabilistic format. The second part of study deals with the reliability analysis of reinforced concrete framed hospital buildings located at Patan of the Kathmandu valley. The building is analysis for the vertical loads and seismic loads as per IS code. The method of reliability analysis carried out considering the

various failure mechanisms. The probability of failure of the building for a PGA level is obtained by FOSM (First Order Second Moment) method; the fragility curves denoting the seismic risk of the buildings for various failure mechanisms are obtained. The annual frequencies of the buildings are determined by combining the fragility curve with the hazard curve of the site.

The result of the study indicates that the probability of failure of building depends upon the mode of failure. It is observed that the building has a high probability failure at PGA level of 0.28g and above.

Thesis Title: **A BRASION RESISTANT CONCRETE FOR HYDROPOWER**

Submitted by: **Pradyumna Lal Pradhan**

Supervisor: **Dr. M. P. Aryal, Mr. Prajwal Lal Pradhan**

ABSTRACT:

Hydropower is the major resource potential of Nepal and one of the major issues to be tackled for its harnessing is related with the excessive damage caused by high sediment flow in Himalayan rivers.

Concrete plays vital role for major construction material in the hydropower projects in Nepal. Case studies of various existing hydel projects in the country have witnessed the premature failure of the submerged hydraulic structures. The causes of damage of such structures may be abrasion erosion, cavitations and different chemical attacks.

In this thesis among the various causes of concrete deterioration of the hydropower structures abrasion erosion has been considered in depth. It has been assumed mat failure of the concrete floors of the hydraulic structures is due to abrasive forces of sediment laden river flow during monsoon. Heavy objects in the form of waterborne silt, sand, gravel rocks and

other debris being rolled or dragged over, or impacted onto the surface cause severe abrasion of concrete floors impinging on the structures during both construction and operation of a hydraulic structure.

In this study sediment transportation data from Marshyangdi River has been collected. The distribution of these sediments along the depth of the channel has been assumed based on Toffalti's approach. Modelling of the sediment flow has been carried out to calculate the impinging force to particular place of the concrete surface. Damage calculation of the concrete surface from the impinging force has been carried out using two different approaches. In the first approach Miner's linear damage theory has been used considering the cyclic behaviour of the loading. In the second approach, finite element analysis has been carried out assuming the concrete slab depth as shell model. The results from each of the models are comparable.

Based on the analytical calculations, minimum grade of concrete has been proposed for a specified lifespan. Finite element analysis provides information about the depth of damage. Overlay of the concrete floor with high grade concrete to this depth can economize the material. Based on literature it has been assumed that the life-span due to the use of fibre reinforced concrete can be increased by about 3 times but this remains the subject of further researeh. Similarly, Compressive strength of stone block seems to be much higher than the required concrete strength arrived from the study for the proposed hydraulic structure. Further studies to this direction will also provide one of the appropriate solutions to the stated problem.

Thesis Title: **STRENGTH EVALUATION CONCRETE BASED ON VARIATION OF SOURCE OF AGGREGATES**

Submitted by: **Mukti Lal Sah**

Supervisor: **Dr. Mohan Prasad Aryal**

ABSTRACT:

Various types of coarse and fine aggregates as construction materials are available in various parts of Nepal. Concept of the use of the best combination of the locally available materials is one of the ways of the best technical, economical and sustainable development of infrastructures. This study is a step forward in research towards the more appropriate use of locally available crushed coarse and fine aggregates as construction materials in concrete production. Altogether six sets of materials in terms of crushed coarse aggregates from three different sources and natural river sands as fine aggregates from four different sources of central and eastern region of the country were used without any modification in the grading. Selection and combinations of the aggregates were based on their availability in a particular locality and their possible use in combination.

Comparison of the physical and mechanical properties of aggregates and concrete grade (M20 to M40) has been made for all of the six sets of aggregate combinations. Compressive

strength of concrete with Mahadevbesi coarse aggregate has been observed to be about 13% to 15% higher than the concrete with Lele coarse aggregate. The same parameter of Sundari crushed aggregate with Khuti Khola sand has been observed about 31% to 15% higher than with Gangajaii sand in M20 and M30 grade concrete respectively but no practical difference is observed in M40 grade concrete.

Tensile strength of concrete made of Lele aggregate has been observed lower values in M20 but higher value in M30 and M40 grade concrete than concrete of Maliadevbesi aggregate. Therefore Lele coarse aggregate can be used for higher grade concrete where the tensile strength requirement is dominating. Tensile strength of concrete with Sundari crushed aggregate and each of sands has been observed 20% higher in M20 grade and the same value in M30 and M40 grade concrete.

Inter-relationships between various strengths of hardened concrete and relationships between destructive and non-destructive strength evaluating parameters of concretes have been developed which can be used for concrete made of similar materials in the construction activities for more reliable quality evaluation.

Thesis Title: **ANALYTICAL MODELING FOR SOIL - STRUCTURE INTERACTION BASED ON THE DIRECT METHOD**

Submitted by: **Jeetendra Man Pradhan**

Supervisor: **Prof. Dr. Ram Krishna Poudel and Prof. Dr. P. N. Maskey**

ABSTRACT:

It is well recognized that the foundation material on which a building is constructed, may interact dynamically with the structure during its response to earthquake excitation, resulting into the stresses and drifts different from the conventionally obtained results.

The integration of the interaction of soil with the structure during seismic analysis leads toward the nearer to the real situation. The effect of such integrated approach is very significant in case of high-rise buildings. This effect results into the economic and more realistic design of structural members.

The present study comprises of comparative study of base shears and lateral drifts of structure due to the soil-structure interaction by the application of different modeling concepts: Fixed base,

Spring base and Finite Element Modeling of Soil-Structure Interaction.

The study is confined to 2-D frame. The structure considered varies from 2 - storeyed to 8 - storeyed. Each frame is analyzed with three concepts. The study basically focuses on the difference in lateral drift and base shear of a structure when different concepts are taken into consideration.

It is found that the roof displacement of the structure is higher in the case of Spring and F£M approaches than in the case of Fixed model, because of displacement of the top level includes the displacement of foundation soil, both in spring and FEM models. In real sense, the response, when analysis is carried out integrating with soil structure, should be less. The base shear is less in the case of FEM and Spring models than that in the case of the Fixed base model.

The incorporation of Soil-Structure Interaction in the dynamic time history analysis greatly affects the value of base shear, which means the Soil-Structure Interaction should not be overlooked in the case of analysis and design of tall structures.

Thesis Title: **SEISMIC STRENGTH EVALUATION AND RETROFITTING OF PUBLIC AUDITORIUM HALLS**

Submitted by: **Ugra Nath Jha**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT:

Most of the seismologists have predicted that Nepal lies in the most vulnerable region of earthquakes. The past earthquakes have supported these facts. The earthquakes of 1934 and 1988 have caused significant damage in Nepal. It is, therefore, needed that whatever structures being built should be seismically strong and sound.

Janakpur is a terian town of Nepal, which also lies in the most vulnerable region of earthquakes. Most of the buildings being built here these days are being constructed without any engineering design and supervision. There are five public auditorium halls in Janakpur. Most of them had been built 10 years ago. Many people gather together into these buildings at a time, any earthquake disaster may cause large destruction of human beings. So these buildings must be strong enough in all aspects. The seismic strength of none them have been determined so far. With this view this study has been undertaken.

Out of these five auditorium halls the main two of them were selected for researeh. These two RCC Framed buildings were not expected to respond to such an eventually without being damaged or collapsed, but results did not come in affirmative. Both the two buildings were analyzed making 3D model in Sap90 Software for Dead Load, Live Load and Earthquake Load as recommended by IS 1894: 1994 Criteria for Earthquake Resistant Design of Structure to find out the response of the structure. The capacities of the various members were determined based on IS 456-2000, Code of Practice for Plain and Reinforced Concrete.

The study reveals that some of the members of the structure have demand forces higher than the capacities of the members, thus making the building vulnerable. The study also reveals that the buildings can be made safe by appropriate measures of retrofitting.

Thesis Title: **CALCULATION MODULE FOR INCREMENT DISPLACEMENT BASED PUSHOVER ANALYSIS OF TRUSS: ANALYSIS OF STATE OF STRESSES OF DECK OF SUSPENSION BRIDGE VIBRATION**

Submitted by: **Shakil Manandhar**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT:

The main theme of this researeh is the calculation of the member stresses and member forces, taking both material as well as geometric non-linearity into consideration, when the space truss deck of a suspension bridge is displaced in torsional mode. The solution of the partial differential equation, defining the torsional vibration of the deck, indicates that the distribution of the rotation of a section along the bridge axis is sinusoidal. Assuming this sinusoidal variation of torsional angle, the nodal co-ordinates of bridge deck at each stage of incremental torsional displacement are calculated. From the data of displaced nodal co-ordinates, member strain is calculated directly. From given stress-strain function, the member forces and eventually nodal forces are calculated.

This concept of "DIRECT CALCULATION OF STRAIN AND BACKWARD CALCULATION OF STRESSES AND FORCES AFTER DETERMINATION OF NODAL CO-ORDINATES OF A SPACE TRUSS FOR EACH STAGE OF INCREMENTAL PUSHOVER DISPLACEMENT" has been adopted for the development of computational module and programming. The interface has been developed and coding has been done in Visual Basic.

The developed program has been used to observe the state of stress of members of space truss deck of suspension bridge under torsional displacement. The effect of orientation of truss members has also been observed and failure sequence of the truss has also been observed by running this program on different models.

It has been found that when a space truss bridge deck undergoes torsional displacement, the most vulnerable members are the diagonal members on the vertical face at the side of the deck. Increasing the number of diagonal members in the side-face will increase the overall torsional moment resisting capacity of the deck.

Thesis Title: IMPACT DUE TO BLAST ON RCC FRAME STRUCTURE

Submitted by: Saroj Karki

Supervisor: Prajwal Lal Pradhan

ABSTRACT:

The terrorist movement in Nepal has forced us to think the effect of blast load on our Building structures. The design of civilian building to withstand the effect of a terrorist blast is unlike the design of Military installation. Military structures are typically associated with a specific mission that must be maintained, and they must remain operational despite the attack; but for the civilian Public Buildings, the single most important design consideration is to design & construct building to save lives in the event of a terrorist attack. There is absolutely no concern for saving the structure other than to save the People. Accepting the fact, commercial public building should be designed to sustain a certain amount of attack; meaning they are designed to allow for limited localized damage - but not the total failure and to permit the rescue professionals to evacuate the survivors from the damaged building.

The common publics building along the Roadside are susceptible to the threat of terrorist attack or vehicular collision. The

conventional Design Practice does not consider the blast load & vehicular collision. Hence the study is concentrated on design of new public building by conventional method of practice for gravity load, Earthquake forces & checked the structures for possible Blast load based on Indian Code of Practice.

The Blast load consists of local hand made bomb with charge weight of 10 Kg at 1m ground zero distance and design blast load as per IS: 4991-1968 *(Criteria for Blast Resistant Design of Structures for Explosions above Ground*) with charge weight of 100 Kg at 30 in ground zero distance.

Every effort is taken to create the model and its study so as to represent the real structural behavior of public building at Kathmandu city- The plan of building, span of beams and height of column are selected based on the commonly used grids on the commercial buildings. In order to represent the buildings in real models, the models are selected based on stories and loading pattern. The models are of three categories based on stories; three stories, five stories & seven stories and twelve categories based on loading pattern. Hence total thirty-six models are considered in researeh. The model are designed for conventional gravity load, Earthquake forces & checked for Blast and Vehicular collision load. The localized effect of blast force in case of local bombs may destroy the columns members. The effect of vehicular collision force is limited to concerned column only; which may be the starting point of progressive collapse.

Thesis Title: ENHANCEMENT OF CONCRETE DURABILITY IN WATER RETAINING STRUCTURES

Submitted by: Ram Chandra Sah

Supervisor: Dr. Mohan Prasad Aryal

ABSTRACT:

Various water retaining structures in Nepal are getting deteriorated *due* to the ingress of water inside the concrete. This has been observed by the author in many case studies. It has been identified through literatures that development of dense and relatively impermeable concrete may be one of the ways to enhance the durability of such structures.

The researeh work focuses on durability of concrete in water retaining structures. Permeability, sorptivity and compressive strength of concrete have been considered as major determining factor to identify the durability, Mineral and chemical admixtures have been- used to enhance the impermeability of concrete. Micro silica in the form of mineral and superplasticizer in the form of chemical admixtures have been used separately and-in combination in three different grades of concrete ranging from M20 to M40.

Experimental investigations on permeability and sorptivity were performed on cylindrical, specimens of size 100mm in diameter and l00mm height, while l00mmx100mmx100mm cubes were used on compressive strength test.

Experimental results show that the reduction in permeability with 5% silica fume has been observed to be 17, 54 and 435 times leaser in coi-icrele grades M20, M30 and M40 respectively compared lo the control ones whereas the same parameter with combined action of superplasticizer and silica fume is about 230 to 540 times for concrete grades ranging from M20 to M40.

In the study relationships have also been developed between permeability and sorptivity, grade of concrete and permeability. Similarly, durability of the tested concrete has been calculated in relative terms.

Thesis Title: **COMPARISON OF CODAL PROVISIONS SET IN CODE OF PRACTICE OF VARIOUS COUNTRIES FOR REINFORCED CONCRETE STRUCTURE**

Submitted by: **Ram Sharan Sayami**

Supervisor: **Dr. Mohan Prasad Aryal**

ABSTRACT:

Many countries have developed Code of Practice for reinforced concrete (RC) design with various assumptions in accordance with their respective social and technological background as well as their experience and knowledge. In Nepal there is no such code of practice in RC design and the designers follow various codes which sometimes may differ to a large extent on various parameters.

This is a study to identify such variations quantitatively. In order to calculate the flexure and shear strength capacities ten different codes have been used for comparison whereas for serviceability design six different codes have been adopted. Some of the parameters considered in this thesis are concrete capacity in flexure, in shear, reinforcement requirements, deflection and cracking.

It has been observed that most of the codes in flexure design consider the effect of concrete grade on compressive stress block

parameters whereas as others do not consider this effect. The variation on some of the values of stress block parameters is up to 50 %. In connection to the shear strength of concrete the variation adopted by the different codes range approximately from 3 Mpa to 11.5 Mpa. It has been observed that the values of flexural capacities of section when calculated based on different shapes of stress block (parabolic-rectangular, triangular-rectangular and simply rectangular) do not vary appreciably.

A case study calculation based on various codes show that for the same services load and beam cross-section the area of total reinforcement required vary by more than two times for M20 concrete. Similarly the variation in total long term deflection of a typical reinforcement concrete beam of span 5m and cross-section of 225 X 325mm by various codes is observed to be about 60 % whereas for the same beam the variation in calculated crack width is about 2.0 times.

Thesis Title: SEISMIC RISK EVALUATION OF FRAMED RESIDENTIAL BUILDING

Submitted by: Prakash Raj Siwakoti

Supervisor: Mr. Prajwal Lal Pradhan

ABSTRACT:

This study is a small endeavour in the direction of accessing the appropriate seismic risk, of inbuilt residential structure under 9" column. Together to this, effort is made to know the contribution of infill panel (9" thick wall) in minimizing the seismic risk of the structure. Hence, the basic objective of the study is to analyze the different residential building constructed within Kathmandu Municipality. Such analysis could forecast the seismic capacity of building. This could give clear insight the inherent seismic risk associated with the different residential building .according to probability of occurrence of Peak Ground Acceleration pertinent to this area.

A total of 50 models, with brick infilled of 25 and bare frame of 25 is analysed by response spectrum methods The spectral pseudo- accelerations were generated by a computer programme for the north-south component of the EI Centre ground motion recorded during the Imperial Valley earthquake of may 18,1940 and were used as input in the Response Spectrum Analysis .The drift is found 3 to 5 times higher in the bareframe of same

building as compared with infill frame and base shear in the infill frame is found 60% higher .As a conclusion the infill is found very effective in minimizing the interstory drift significantly up to spectral acceleration of .15*g though it be found satisfied in .1 *g for bare frame approach. Despite, such contribution of infill it cannot be relied beyond spectral acceleration of .125*g as would attract higher inertia force thereby failure of its member. But the bare frame is found critically functional for .l*g and probability of occurrence in Kathmandu of such PGA is in the proximity of 37 %, thereby 37% risk of such residential building .But, incorporating the effect of infill panel and its critical tolerance limit up to PGA of .125*g reduces the seismic risk in the range of 20 % in normal fifty years life span of residential buildings.

Thesis Title: LONGITUDINAL REINFORCEMENT IN RCC BEAM IN TORSION

Submitted by: Tej Raj Thapa

Supervisor: Dr. Mohan Prasad Aryal

ABSTRACT:

Reinforced concrete members subjected to torsional moment may cause excessive shearing stress and severe cracking may develop beyond the serviceability limits, if torsional reinforcements are not provided. Torsion mostly occurs with bending, shear or axial forces or their combination Many researehers have investigated that longitudinal and transverse reinforcement is used in equal volume in pure torsion and that works well- But the behavior of the members subjected to combined torsion is rather complex.

An experimental study has been carried out to investigate the behavior of longitudinal reinforcement in RCC beams under combined loading. Six types of beam specimen in connections to longitudinal reinforcements have been adopted and three types of lengths, 60 cm 95 cm and 130 cm are used for torque moment ratio of one, two and three. Concrete grade and transverse reinforcements are constant. The effects of longitudinal reinforcements have been studied for various percentages of reinforcements. The concrete grade used was ofM30 and

reinforcement Fe 415 and 500 for longitudinal bars and stirrups respectively. Tests of thirty-one beams were performed in the laboratory using universal testing machine with computer interface along with other accessories developed to enhance the required testing facility.

The beams were tested for torque moment ratio more than one, so all the tests were torsion dominant. Tests revealed that ultimate torque did not vary much with the variation of torque moment ratio as one two and three, but it increased with increase of longitudinal reinforcement when the torque moment ratio was two. Experimental data also cleared that cracking torque increased slightly with the increase of torque moment ratio and also with the increment of longitudinal reinforcement in flexural tension side. But increase of longitudinal reinforcement in flexural compression face made no difference to the cracking torque. Post-cracking torsional rigidity was not influenced by variation of torque moment ratio, but pre-cracking torsional rigidity decreased with the increase of torque moment ratio. The analysis of the laboratory test data also revealed that torsional ductility factors decreased when the torque moment ratio was increased

Thesis Title: **COMPARATIVE ANALYSIS OF ELASTIC AND PLASTIC NON-LINEAR IN STEEL FRAME STRUCTURE**

Submitted by: **Sanjeev Adhikari**

Supervisor: **Prof. Kozo Wakiyama, Mr. Prajwal Lal Pradhan**

ABSTRACT:

This study is a small effort in the direction of preparing an analysis model to aid the development of the appropriate design provisions incorporating the effects of nonlinear analysis for steel frame structure. One of the basic objectives of the study is to analyze the different computer simulation models for steel frame and develop a simple appropriate effective model to find the responses of non-linear including both material and geometric non-linear using yield function. The second objective is to use the appropriate model and compare the different responses in elastic, material non-linear and geometric non-linear steel frame of multistoried buildings.

All models are carried out using FORTRAN programming and small experimental work is carried out in Osaka University, Osaka to find yield stress of steel. After developing computer programmed, it is compared with SAP2000. In all the models,

lateral load capacity of the frame was determined by increasing the lateral load from increasing top floor deformation in regular interval till the frame totally get fully plastic. The analytical results of strength and stiffness were compared with the experimentally obtained data and the appropriate model selected for the analysis of multi-storied (9 storied taken) building frame as an example. The different responses obtained by the conventional analysis approach and the model analysis approach was studied in this 9-storied building frame.

Thesis Title: PROPERTIES OF STRUCTURAL WOODS, STRENGTH OF TRADITIONAL WOODEN TRUSSES AND THEIR JOINTS

Submitted by: Ashok Kumar Yadav

Supervisor: Dr. Rajan Suwal, Mr. Haridarshan Shrestha

ABSTRACT:

There are different types of wooden truss has been used in the traditional structure with different joint condition. The ultimate load capacity of that structure is not known. Data's are not available for truss and joint which are safe in actual and apparent factor of safety for given cross-section and joint condition.

For the thesis, physical and mechanical properties of timber are tested in laboratory. Compressive strength, bending strength, tensile strength and shear strength are determined in laboratory according to their related IS Code. These strengths are further used in the analysis of truss.

The model of truss of Patan Museum and Patti of Rhaktapur are made in ratio of 1:2 in laboratory considering the same cross-section and length of Member and detail of joint. In testing the truss in laboratory, it has been seen that the truss of Patan Museum meets the design criteria. It is safe in actual and

apparent factor of safety. The near value of factor of safety shows that the truss is economical in design consideration.

The truss of Patti of Bhaktapur has too much apparent factor of safety that means much safer in load criteria and failed with actual factor of safely. Large value of apparent factor of safety indicates that the cross-sectional area of the truss member is too much than requirements. That means the truss is uneconomical- So the cross-sectional of truss member can be reduced. The failure in joint shows that member of truss is much stronger than Joints.

Thesis Title: **PERFORMANCE OF CEMENT MORTAR IN BRICK MASONRY**

Submitted by: **Uma Shankar Sah**

Supervisor: **Dr. Mohan Prasad Aryal**

ABSTRACT:

This researeh focuses on brick - mortar interaction in brick masonry under vertical and lateral loading. For this purpose experiments have been performed to determine the compressive strength, tensile strength and elastic constants of local and machine-made bricks as well as mortars individually. Four different grades of mortar in terms of cement-sand ratios as well as four different water-cement ratios for each different combination were tested.

The effect of mortar in brickwork has been tried to explain with the help of analytical and experimental results. Based on the brick-mortar interactive behavior under the vertical loading, an analytical relationship has been developed to find the strength of brickwork prism- Similarly, based on the tensile strength test of brick and mortar, an analytical relationship has been proposed to arrive at the optimal type of mortar for brickwork under lateral loading using normal stress theory. From the experimental result it has been observed that the bond between brick and mortar

plays dominating role in the strength of brickwork under lateral loading.

Thesis Title: EARTHQUAKE SCENARIO AT BHAKTAPUR MUNICIPALITY

Submitted by: Suman Nursing Rajbhandari

Supervisor: Prof. Prem Nath Maskey

ABSTRACT:

This researeh focuses on the possible scenario after a major earthquake strikes Bhaktapur municipality. Although RCC structures also exist in the area, a special emphasis was given to the vulnerability analysis of masonry structures. The response of brick masonry walls to in-plane horizontal load induced during seismic events was analyzed manually assuming cantilever action as well as by computer using finite element model. Here blocky nature of brick masonry was neglected and masonry was assumed as mess element. Suitable model was developed and analyzed using shell element in STAAD, Analysis was performed using seismic coefficient method. To check the time period of the buildings, free vibration analysis was performed for two buildings. Results showed that the masonry buildings existing in Bhaktapur municipality have time period less than 0.25 seconds. Analysis showed that the comers and masonry around openings are most vulnerable parts to earthquake load. Piers between openings are the most vulnerable parts in masonry. Maximum shears stress occurs around mid height of piers and

top and bottom of piers have high tensile or compressive stress. Most of the failure modes are associated with tension. The analysis often buildings shows 60% of buildings are vulnerable to earthquake in Bhaktapur Municipality, Similarly study on status of other services that is important during earthquake disaster and probable loss of life was done. All these works will be useful for pre-earthquake disaster management in the form of retrofitting, mitigation, preparedness etc. as well as post earthquake disaster management.

Graduation Year 2003

Thesis Title: **VULNERABILITY ASSESSMENT OF BUDDHIST MONASTERIES (BAHA / BAHI) OF PATAN**

Submitted by: **Surya Narayan Shrestha**

Supervisor: **Prof. P. N. Maskey**

ABSTRACT:

Many Bahas and Bahis (Buddhist monasteries) of Kathmandu valley are valuable part of the historical, monumental and traditional cluster of heritage. Kathmandu valley being seismically active area, the seismic vulnerability of these structures is crucial. In most of the cases their vulnerability is unknown. In view of these facts, the seismic vulnerability assessment of Bahas/Bahis of Patan city is taken as the prime objective of this study. The study also intends to identify the basic factors to the vulnerability of the structures and to outline the strengthening measures.

In the study, four Bahas and Bahis of different kinds of Patan city are selected and evaluated with detail numerical evaluation procedure and qualitative evaluation procedures- For detail numerical evaluation, the structure is modeled as finite elements and analyzed by seismic coefficient method as recommended in IS 1893-2002. The results of the analyses show that the Baha and

Bahi type structures are very stiff structures with fundamental natural time period less than 0.50 second. The dominant mode of failure in these structures is (ensile failure unlike the shear mode of failure in masonry structures, in the general- Parts of masonry walls adjacent to the openings, comers and junctions are critical locations of the structures.

Qualitative evaluation procedure also indicates that the dominant failure mode in these structures is not due to shear, because these structures have heavy area of walls in the lateral force resisting system. The structures are the well-built type of mud mortared brick masonry structures and their vulnerability is due to the inherent weakness in the mud mortared brick masonry and also due to the lack of integrity of different structural walls and deterioration of the materials. Most of the Baha/Bahi shows lack of proper repair and maintenance, thus increasing the vulnerability.

Thesis Title: SEISMIC CAPACITY EVALUATION OF MASONRY SCHOOL BUILDING

Submitted by: Ram Kumar Sah

Supervisor: Mr. Prajwal Lal Pradhan

ABSTRACT:

The objective of proposed researeh is to evaluate the seismic capacity of existing school building which are basically constructed with plain brick masonry for future earthquakes. Suitable modeling is developed and analyzed using shell and Inline model in SAP2000 software. There are three numbers of school buildings of different types have been modeled and analyzed. Analysis is performed using Seismic coefficient method as recommended by IS 2000. The results show that the school buildings constructed with plain masonry of Saptary district of Nepal are seismically vulnerable. The most crucial parts of buildings are the piers between openings. Most of the failure modes are associated with shear & tensile stresses.

Thesis Title: **QUALITY EVALUATION OF CONCRETE USED IN BUILDING CONSTRUCTION IN KATHMANDU VALLEY**

Submitted by: **Arna Raj Silwal**

Supervisor: **Dr. Mohan Prasad Aryal**

ABSTRACT:

Quality, the degree to which it fulfills the said requirements, is not an absolute term. It can only be compared with the established standards. Many decisions during design and construction are associated with cost. But it is not wise to associate quality with cost, as "quality is priceless". Rather cost of poor quality is much higher than that of good quality.

Study in this thesis work basically focuses the evaluation of quality of concrete presently being used in building structures. Here, quality evaluation means the evaluation of characteristics of structures' concrete in terms of performance. Using the same material proportion, characteristics of structures' concrete depends upon the quality of materials and quality of production process. This thesis work covered variation of concrete quality during production process.

Effect of two major factors, water cement ratio and curing, which govern the quality of concrete during production process, are studied in this thesis. Study is based upon both destructive and

non-destructive testing conducted at laboratory and at sites. Destructive testing was for three parameters - compressive strength, tensile strength and permeability. Similarly rebound hammer test and ultrasonic pulse velocity testing were performed as nondestructive testing.

Data of the study show the significant effect of both the factors, water cement ratio and curing, on quality of concrete. Design strength of concrete is found to be much lower than what it assumed to be. Variation was observed in all studied parameters-Average variation of strength due to effect of water cement ratio and curing is found to be in the range of 56% in terms of compressive strength, 69% in terms of tensile strength and 17% in terms of rebound average value. Variation of strength is different for different

Thesis Title: STUDY ON THE EFFECT OF PARTIALLY INFILLED BRICK WALL IN REINFORCED CONCRETE FRAME

Submitted by: Ram Krishna Adhikari

Supervisor: Mr. Prajwal Lal Pradhan

ABSTRACT:

This study is a small effort in the direction of preparing an analytical model to aid [he development of the appropriate design provisions incorporating the effects of partially infilled brick wall in reinforced concrete frames. The basic objectives of the study is to analyze the different computer simulation models for the partially infilled frame and the responses are compared to the bare frames and full infilled frames of multistoried buildings,

Frames having different stories and bays such as one bay frames having 1,3,5,7 stories and two bay frames having 1,3,5,7 stories has been selected and analyzed here. The analytical models include bare frames, frames with 1/3rd infill, 2/3rd infill and full infill wall. All the partially and fully infilled frames were analyzed using both the diagonal strut and frame shell approaches.

The lateral load in all type of models of the same size of frame was kept same. The output was checked for one load combination only. The responses obtained on different partially

infilled frames, full infilled frames and the bare frame were compared, Diagonal strut model gave the highest shear force in column, which is about 70.7% and 33.7% more than in one and two bay multistory bare frame. The shear force given by shell model is very close to the results given by bare frame model. But the bending moment in diagonal strut and frame-shell approaches is less as a comparison to bare frame model. The stresses in infill panel were observed maximum at low infill height.

Non-linear static pushover analysis was carried to determine the ultimate base shear capacity for varying infill height in bare frame, diagonal strut and frame shell modeling. The base shear capacities of partially infilled frames were observed greater than the bare frame but lesser than the full infilled frames. The base shear capacity increased with the increase in infill height.

Thesis Title: **STRUCTURAL ASSESSMENT OF TYPICAL MASONRY BUILDINGS IN NEPAL**

Submitted by: **Hima Gurubajracharya**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT:

This thesis deals with the study on structural assessment of typical housing system in Pokhara of Nepal. The housing system targeted for low income and middle income families is considered for the study. The typical two storey residential buildings constructed. In hollow block masonry are assessed for structural performance during possible earthquake. The buildings are modeled as a combination of frame and shell elements. Three different types of models are considered for analysis of the buildings. Static linear and dynamic analysis is performed for the assessment of the buildings. The performance of all the buildings is compared in terms of stresses and displacements. The strength evaluation of the building structure is carried out in detail.

From the results of the study it is found that the hollow block masonry panels in the buildings have a good contribution in resisting shear stresses. Major failures located are due to tensile stress developed adjacent to the openings and also due to inadequate bearing area provided for beams. Better performance,

however has been observed in buildings with small panel sizes, small or no openings, no high concentration of direct point loads and panels uniformly located along both the height and the plan of the building.

Thesis Title: EARTHQUAKE RESPONSE OF DHARAHARA

Submitted by: Ganga Bahadur Basnet

Supervisor: Prof. Dr. P. N. Maskey

ABSTRACT:

Bhimsen Stambha (Dharahara) is the unique historical monument located at the heart of Kathmandu city. The 178 years old brick masonry structure carries a heritage value and is of areheological importance. The damage records of 1934 earthquake shows a substantial damage of the structure which was rehabilitated to its original shape. The conservation of the structure of national importance needs the evaluation of its seismic safety for future earthquakes. For the study, the material properties are determined by non-destructive testing and from prevailing codes and literature. The structure is modeled basically as shell fine elements with some frame elements. The seismic capacity evaluation is then carried out using seismic coefficient and response spectrum methods as per prevailing codes. Results show that the fundamental lime period of Dharahara has been found as 1.67 seconds. First two modes of Dharahara are high and closely spaced and these two modes contribute to the total response with similar significance. Most of the failure modes are associated with shear, tensile and compressive stress. Even though the dominant type of failure is shear failure. Height from

21m 10 28m of Dharahara is the most vulnerable part due to shear as the earthquake response. The expected drift values exceed the allowable limit. These results indicate less rigidity of the structure. According 10 the failure analysis results, decision has to be taken concerning to strengthening of the Dharahara. The structural overlay reinforced concrete around the outer wall has been tentatively proposed *as* the possible retrofitting option.

Thesis Title: **STRCUTURAL EVALUATION OF RESIDENTIAL BUILDINGS IN LANDSLIDE: A CASE STUDY OF CHOBHAR LANDSLIDE**

Submitted by: **Dhruba Tripathi**

Supervisor: **Prof. Dr. Ram Krishna Poudel and Dr. Sanjeev Shah**

ABSTRACT:

This study is focused on study of landslide and its effect on residential building. For this purpose, a slow moving landslide at Chobhar is studied and structural evaluation of a RCC framed structure is done for the landslide induced displacement at the foundation. Two aspects of the problems are addressed in this study a) landslide study b) structural evaluation of building. Slope stability analysis and structural evaluation are performed in finite element principle. Commercially available software are used for this purpose.

Based on the data collected from the site, a soil slope model is prepared for the slope stability analysis. Then a soil-structure model is prepared by taking the area extending five times the width of the structure and five times the depth of the foundation. The nodal displacement values obtained from the slope stability analysis is transferred to the soil-structure model. The soil-

structure model is regarded as the true picture of the actual site condition and on its basis building frame is analyzed for different landslide induced displacements at the foundation level.

The study shows that the landslide is caused due to the inherent soil property and high groundwater. The groundwater table reducing measures are proposed to enhance the slope stability. It is seen from the analysis that the foundations of the building are the most critical members to fail. The moment resisting capability of the foundation of the building under consideration is below the required level and hence needs to be redesigned to withstand the landslide induced stresses.

Thesis Title: **THE BEHAVIOUR AND PERFORMANCE OF CONCRETE WITH RICE HUSK ASH AS LOCAL MINERAL ADMIXTURES**

Submitted by: **Deepak Thapa**

Supervisor: **Dr. Mohan Prasad Aryal**

ABSTRACT:

One of the main challenges facing the concrete industry now in Nepal and also in other South Asian Countries is to meet the challenges posed by enormous infrastructure needs due to rapid industrialization and urbanization. Hence the importance of utilization of pozzolanic industrial-by-products (fly ash, condensed Silica fume, RHA etc) as partial replacement of cement cannot be under-estimated, and are increasingly being used. Therefore this researeh work focuses on the utilization of RHA as local mineral admixtures for partial replacement of cement in Nepalese condition.

The RHA were obtained and collected in as-it-is condition from two different sources of Nepal. A series of laboratory tests were carried out to find the physical properties, chemical compositions, mechanical properties as compressive strength and tensile strength and durability through carbonation and permeability tests. Particle size distribution carried out by the

sieve as well as hydrometer analyses show that 60 percent of the processed RHA from both sources are greater than 75 microns and the rest - less than 75 microns.

The major chemical constituent of RHA was found as silica, which is about 80 %. It has been observed that RHA particles tend to increase water demand compared to control concrete for the same level of workability. The compressive strength test conducted on M25 and M35 grade concrete indicate that the maximum compressive strength for a mix of 0 to 15 % replacement of cement with RHA a[the age of 28 and 91 days of curing and the rate of increment of compressive strength from 28 to 91 days for 0 to 15 percents of RHA with compared to control concrete have almost same value.

The study shows that the replacement of cement with 15 % RHA has marginal improvement in flexural strength and very small reduction in coefficient of permeability. Experimental investigations on compressive strength were performed on cubical specimens of sizes 100*100*100mm while cylindrical specimens of sizes 100 mm dia. and 100 mm length were used on permeability test.

Thesis Title: **APPLICATION OF ARTIFICIAL NEURAL NETWORK IN THE ANALYSIS OF IN - FILLED FRAME**

Submitted by: **Alin Shakya**

Supervisor: **Mr. Prajwal Lal Pradhan**

ABSTRACT:

This researeh is the small effort in the seareh of the alternative approach for analyzing the infilled frames. In the present practice, the infilled walls are considered to be non-structural and ignored in the analysis, because there is no proper and easy method available for considering the effect of the in-filled. Even after more than four decades of researeh on the behavior and performance of in-filled frames, no viable solution is recommended for the assessment of in-fill strength to the lateral loads, considering non-linearity. The FEM models are normally incapable of considering all the affecting factors such as non-linear behavior of the infill materials, lack-of-fit, non-homogeneity of the materials etc.

Neural networks are artificial intelligence algorithms for cognitive tasks, such as learning and optimization. The motivation for neural networks came from attempts to simulate the processes of the human brain. Neural networks are of interest

because of their ability to learn to make decisions, and to draw conclusions from examples without .knowledge or the underlying rules. A method based on ANN can accommodate all parameters of uncertainties. So the main objective of this researeh is to study the applicability of the ANN methodology in the analysis of in-filled frames.

A totally generalized ANN program is developed in Visual Basic programming language, and the program is validate using the actual lab tested data from Warangal University (India). Several numbers of testing is done in the analysis of infilled frame, varying different parameters such as no. of iterations, learning rate, no. of hidden layers, activation functions etc.

A Bipolar Sigmoid function is found appropriate to be used in structural analysis problems. The Comparison shows the closeness between the neural outputs and the target outputs, which demonstrate the power of the ANN paradigm. So we can conclude that, if enough study is done in this field, one day, this approach will either fully replace some conventional methods or complement the conventional methods to enhance its capabilities.

Thesis Title: **PROBABILISTIC SEISMIC INPUT FOR POKHARA OF NEPAL**

Submitted by: **Yashwant Vikram Shah**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT:

The study on 'Probabilistic Seismic Input for Pokhara Region' is carried out in two parts: in the first part, the probabilistic seismic hazard analysis, is carried out for the Pokhara Valley considering 6-active faults as earthquake sources, the recurrence law proposed by Gutenberg-Richter is used. The intensity of earthquake at the center of Pokhara city in terms of PGA is obtained by adopting the attenuation law proposed by Joyner & Boore (1981) and assuming Poisson's process for occurrence of earthquakes- Using conditional probability of magnitude of earthquake and source to site distance, the probabilistic seismic hazard curve at the bedrock is obtained. In the second part of the study the risk consistent normalized response spectrum at the bedrock for various intensity level is first obtained using empirical relationship of the spectral acceleration ordinate with the conditional probability, magnitude and source to site distance of earthquakes. The risk consistent response spectra for various ranges of PGA value are used to simulate time-history at the bedrock. The free-field ground motion and the seismic input in

terms of risk consistent response spectra at 5% damping ratio at 5-different sites are obtained by carrying out one-dimensional wave propagation analysis for the soil deposits. Seismic hazard curves at the free-field of the 5-sites of Pokhara Region also are obtained considering the soil amplification effect. The results of the study show that the ground motions at the bedrock and at the free-field are drastically different, and the risk consistent seismic input also varies from site to site. It is found that the soil amplification factor and hence the response spectral values are high for the sites adjacent to the lake.

Thesis Title: **EVALUATION OF LOCAL CARRYING CAPACITY OF AREHI BRIDGE (KALIGANDAKI RIVER BRIDGE)**

Submitted by: **Shyam Thapa**

Supervisor: **Prof. Dr. Ram Krishna Poudel and Dr. Sanjeev Shah**

ABSTRACT:

There is only one Box - Shaped Areh Bridge and is the longest areh bridge in Nepal. Areh bridge construction is quite difficult since the areh cannot support itself until it is completed. The failure of the areh bridge is very much difficult and hazardous to the public and to the Nation. Hence to preserve and to strengthen, the Load Carrying Capacity of the Existing Areh Bridge is essential to allow the safe loads and hence for better durability or longevity of the bridge life.

The maximum bending moment, maximum shear force and critical deflection points for different load combinations are analyzed for finding out the critical sections using SAP2000. Failure mechanism (hinge formation) and critical deflection of the bridge members are observed using POA (DI/IL) method, it is found that the crown of the areh is the most critical for which

the critical point load is calculated by iterating for the analyzed critical displacement.

The critical load (at crown), which produces critical hinge with the dead load, is found whose value is 2899 KN (downward) for corresponding displacement of 0.071m (downward). Since the bridge has been completed in 1998 A.D., the physical condition is in Good/Fair condition. The Rating of the Bridge for Bending Moment and Shear Force are found as 2.15 and 6.2 respective. Both the conditions are satisfactory and die load prescribed should not be exceeded at the crown of the bridge.

Thesis Title: **SEISMIC VULNERABILITY ASSESSMENT OF ADB/N BUILDING**

Submitted by: **Sanjeev Regmi**

Supervisor: **Prof. Dr. Ram Krishna Poudel and Dr. Sanjeev Shah**

ABSTRACT:

The existing structures built in seismically vulnerable regions at different times need to be assessed in view of the changing codal provisions. The various buildings owned by ADB/N and located in different parts of the country are the subjects of seismic assessment. Of the many buildings, two are selected for a detailed assessment in the study. Both the buildings are frame structures, built in different time with different modes of design & supervision. The first one is located at Siraha while the other one in Katmandu valley. The buildings are analyzed with a 3D model using SAP2000 software for all the possible actions including possible earthquakes. The capacities of different members of the buildings are compared with the response. From the result of the study, it is found that some of the members are subjected to stresses higher than their capacities making the building vulnerable. The appropriate strengthening and retrofitting measures are proposed to improve the performance of the buildings.

Graduation Year 2004

Thesis Title: **FAILURE STUDY OF RC FRAME STRUCTURE DUE TO SIN KHOLE FORMATION IN POKHARA VALLEY**

Submitted by: **Krishna Raj Adhikari**

Supervisor: **Mr. Prajwal Lal Pradhan**

ABSTRACT:

The study was basically concerned on the effects of sinkhole on building structure in Pokhara valley. For this purpose, the most effected area and some effected buildings were observed. General information about the characteristics, of soil and types of buildings in sinkhole prone area were collected and models for computer analysis were prepared. Further then, altogether 364 different models were analyzed using SAP 2000 and the results relating to vertical and horizontal displacement at footing level and floor level are extracted for interpretation.

In sinkhole prone area of valley, the loose weathered grey topsoil is up to 3 in depth from the surface and most of the building structures are Reinforced concrete framed with one storey to three storey. In the site, when a sinkhole forms, the soil settles

within the certain range. The settlement of soil due to subsidence eventually has an effect on the structure located closer to it.

Analysis of residential one bay frame from one storey to three storey with sinkhole model shows that the differential settlement of footing is the main cause of failure of structure. The failure of structure also depends on the location of structure from the edge of cavern. Differential settlement of structure at 1 m distance from edge of cavern is 20 times more than the same structure at 4 m distance. Besides this, the storey sway with out any external lateral loads has also significant effects on the structure due to sinkhole.

Thesis Title: **PERFORMANCE OF BRICK MASONRY UNDER VARIOUS STATIC LOADING CONDITION**

Submitted by: **Iswari Prasad Bhattarai**

Supervisor: **Dr. Mohan Prasad Aryal**

ABSTRACT:

This researeh work focuses on the behaviour of brickwork under static loading. Various types of stresses in local brickwork - compressive, tensile, shear and bond have been studied through experiments. Modulus of rupture is obtained from tests with stresses parallel and perpendicular to the bed joint. Splitting tests are also conducted to identify the tensile strength. Shear strengths of brickworks are investigated with as well as without precompression. Elastic constants in terms of modulus of elasticity and Poisson's ratio of different types of brickworks have also been identified. Two different types of brick - local and machine made and four different grades of cement sand mortar - 1:2, 1:3, 1:4 and 1:6 have been used in the study. Based on the experimental investigation, relationships between various types of strength have also been obtained. Similarly, analytical relationships have also been developed to identify the basic compressive strength from the available brick unit strength. Experimental data are also used to arrive at the analytical relationship.

Thesis Title: **DEVELOPMENT OF HIGHWAY BRIDGE LOADING FOR NEPAL**

Submitted by: **Surya Bahadur Bhat**

Supervisor: **Prof. Dr. Hikmat Raj Joshi, Dr. Mohan Prasad Aryal and Dr. Roshan Tuladhar**

ABSTRACT:

Most of the countries have their own standard bridge live loading for the design of highway bridges. Nepal, so far, does not have its own highway bridge loading standard. So, for the design of bridges various other standards are used. Such approach is not only reflecting the actual effect of the vehicles plying on the roads and bridges, but also creating inconsistencies in bridge capacities. Differences in bridge capacities designed by the American and Indian standards (AASHTO and IRC) are more than 50% in many cases. However, they have been considered as equivalent by Nepal Road Standard 2045. Such inconsistency can be avoided only after the development and use of National Bridge Loading Standards.

This is a research work towards developing Nepal's own Live Loading Standards in road bridges. While developing such loading, actual traffic compositions have been considered on different sectors of the roads of Nepal. The frequency of occurrence of axle loads is considered through Poisson's

probability distribution. Based on the effect of existing vehicles, a representative vehicle has been developed and its effect in terms of responses is compared with other loading standards and found satisfactory. Based on the study, fatigue effect of the proposed vehicle is also analogous with that of the existing vehicles. Impact effect of vehicles has also been studied and an empirical formula has been developed. Consideration of weight-in-motion (WIM) system of existing vehicles however more appropriate, as stated by various authors was not possible within the scope of the available traffic data collected in the Department of Roads. The proposed vehicle consist of uniformly distributed load of 15 kN/m throughout the loaded span, 150kN knife-edge load for bending moment and 220 kN knife-edge load for shear force .

Thesis Title: **STUDY OF HIGH PERFORMANCE CONCRETE WITH ADMIXTURES**

Submitted by: **Rohit Kumar Bisural**

Supervisor: **Dr. Mohan Prasad Aryal**

ABSTRACT:

This research study has the objective to explore the possibility of production of High Performance Concrete in Nepal using locally available materials and admixtures. Coarse aggregates from ten sources were investigated on their physical and mechanical properties. Out of them aggregates from four sources with two nominal sizes 10 and 20 mm were selected for further studies. Behavior of three types of superplasticizers was studied. Only one type was selected for concreting works. Behavior of control concrete and superplasticized concrete of different sources were studied in the preliminary stage. A constant slump was maintained in all cases.

Only two sources of aggregates of 20 mm size reflecting better result from preliminary trial were selected for final trial with silica fume concrete. They are Mahesh Khola and Godavari source. Two different doses of silica fume (7.5 % and 15 %) in the concrete mix were chosen for final study. Behavior of control

concrete and superplaslicized silica fume concrete of two sources were studied in the final stage.

The 28 days strength of Mahesh Khola (20 mm) superpiasticized concrete was in the range of 56 MPa at w/c ratio of 0.25. The 28 days strength of same source but with superplasticizer & 15 % silica fume was in the range of 57 MPa at w/b ratio of 0.32. Godavari (20 mm) sample has the 28 days strength in the range of 55 MPa with superplasticizer at w/c ratio of 0.31 and 55 MPa with the use of 15 % silica fume & superplasticizer at w/b ratio of 0.37. The 91 days strength of 15 % silica fume concrete of Mahesh Khola and Godavari (20mm) sample was in the range of 77 and 72 MPa respectively. There is a possibility to increase the strength of superplasticized silica fume concrete up to 94 & 82 MPa for Mahesh Khola & Godavari source respectively by controlling w/b ratio.

15 % silica fume concrete is more durable than control concrete and 7.5 % silica fume concrete against deteriorating effect of hydrochloric acid and sodium sulfate. The silica fume concrete has very small permeability in the order of 10^{-15} meter/sec. Silica fume concrete is durable against acid attack. The effect of sodium sulfate on concrete is suggested for elaborate study.

Thesis Title: **STANDARDIZATION OF SAND AND QUALITY EVALUATION OF LOCAL SANDS**

Submitted by: **Kamal Bicram Shah**

Supervisor: **Dr. Mohan Prasad Aryal**

ABSTRACT:

The records of past earthquakes including that of 1934 Nepal Bihar earthquake show that the Lubhu region was heavily effected. Neither seismic hazard analysis nor vulnerability study has been carried out for the region. However, number of buildings and other infrastructure are increasing without proper consideration of the seismic risk. Investing of the seismic risk of historically important settlement of Lubhu is of prime concern.

In the first part of the study, Probabilistic Seismic hazard analysis (PSHA) of Lubhu region is carried out. The seismic sources surrounding the area are considered and the occurrence of earthquake is assumed to be Poisson's process. The attenuation laws proposed by Kawashima and Joyner & Boore are used. Soil amplification factor of the local soil sediment is determined by one dimensional wave propagation analysis. Risk Consistent response spectrum has been developed using extended PSHA. The result of the probabilistic seismic hazard analysis show that

the level of peak ground acceleration with 10% probability of exceedence in 50 years period is considerable.

In the second part, the vulnerability of existing masonry structures are investigated using seismic coefficient method. The response of the buildings with unreinforced brick masonry walls is obtained by finite element approach using shell elements. The result of the study shows the masonry structures existing in Lubhu are very stiff with fundamental time period less than 0.2 seconds. The vulnerable sections and areas of the buildings for the estimated peak ground acceleration level due to earthquake in future are identified.

Thesis Title: **ATTENUATION OF GROUND MOTION FOR THE REGION**

Submitted by: **Huma Kant Mishra**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT:

The evaluation of seismic hazard to identify the seismic input at a site largely depends upon the right choice of attenuation law. The attenuation laws in the form of PGA relating with the earthquake magnitude and source-to-site distance with oilier seismological parameters are popularly used to determine the seismic input at a site. These laws, in general, are derived from strong ground motion records for a particular region. Himalayan region of Nepal is one of the seismically active regions in the world. But, unfortunately the earthquake records are not enough to develop independent empirical attenuation relationship for the entire region. The strong motion database available for (lie region can he enhanced by milking use of records from SR.R. of 1988 earthquake, MMI intensity records of IK33 and 1934 earthquakes and oilier strong motion areelerograph records.

Identification of the attenuation laws best suiting the region is the only alternative to evaluate the seismic hazard analysis to determine the seismic input for the analysis of structure in the

region. The process consists of five categories of evaluation to arrive at the suitable choice namely; a) by statistical analysis of calculated PGA values, b) by construction of seismic hazard curves, c) by development of attenuation law with the available limited earthquake records, d) by comparing the results with the available records and c) by formulation of normalized response spectrum. The major findings of the study are: i) to use the newly developed empirical attenuation relationship to estimate the approximate seismic input parameter for the region and ii) the attenuation laws proposed by Youngs et al. (1997), Donovan (1973), Cornell (1979) and Crouse (1991) are the most suitable for Nepal region unless a better alternative is found**.**

Thesis Title: SEISMIC CODES AND REGULATIONS FOR DESIGN OF STRUCTURES

Submitted by: Bidur Kafle

Supervisor: Prof. Dr. Prem Nath Maskey

ABSTRACT:

The design and construction of structures are carried out to satisfy the local requirements normally stipulated in the codes of practice. The regulations for design and construction worked out for a region may not be suitable for other regions. Codal provisions of codes of developed countries may reflect the recent technological development, which may be incorporated in other countries for betterment of the construction quality.

Out of various seismic codes available, four codes: Nepal National Building Code (NBC 105:1994), Indian Standard Codes (IS 1983:1984 and IS 1983: 2002, Part I), Uniform Building Code (UBC: 1991) are considered for the study. The study consists of two major parts. The first part deals with different important clauses and their rationale. The second part deals with a numerical study; a typical 5 storeyed RC framed building is analyzed according to different codes. The main focus has been given to the seismic coefficient method of analysis. Other clauses of the codes are reviewed in detail. The fundamental time period

of the building is obtained from free vibration analysis and is compared with empirical formulae of the codes. The seismic coefficients, base shears, stresses and displacements are obtained using different codes and compared. The member forces and drifts have been obtained by using SAP 2000 software and the results obtained by using different codes are then compared.

The results of the study indicate that the base shear and the drift value by IS 1893:2002 are highest among other codes and hence conservative. It is observed that the results obtained by the load combination including dead load and earthquake load are more than other load combinations.

Thesis Title: **SEISMIC PERFORMANCE OF GROUT FILLED CONCRETE BLOCK STRUCTURES**

Submitted by: **Sajeev Shakya**

Supervisor: **Prof. Dr. Prem Nath Maskey and Prof. Dr. Hikmat Raj Joshi**

ABSTRACT:

The cost and time required are two dictating factors for construction of ever increasing low-rise buildings in the developing countries. Low rise buildings with hollow concrete block used as infill as well as frame elements might be one of the ways out for the purpose. Seismic performance of such buildings is of utmost importance. This study deals with the investigation of seismic performance of grout filled concrete block structures.

The first part of the study includes determination of material properties. For the determination of compressive strength parameters of hollow and grout filled concrete block structures, various cubes and prisms of standard sizes are tested in laboratory. The observed values are compared with values derived from different literatures and final properties values are established for analysis.

In the second part, a typical three storey building with hollow concrete block infill material is analyzed and investigated for its structural performance. The building is first modeled with grout filled concrete block with reinforcement as structural elements such as beams, columns and lintels. Its seismic analysis is carried out by seismic coefficient method and the results are compared with those of typical R.C. frame structures with hollow concrete block as infill material. The investigation is carried out in terms of time period, stresses and storey-drift.

From the result of study it is found that the grout filled concrete block structures with hollow concrete blocks as infill material, are feasible for low rise buildings. It may be a better alternative for conventional framed RC buildings with infill walls.

Thesis Title: **NON-LINEAR ANALYSIS OF REINFORCED CONCRETE BEAMS**

Submitted by: **Rupak Raj Bista**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT:

The understanding and need of structural behavior at nonlinear ranges are long known. However, there is a lack of trend to perform computer simulation of any structure before they are designed. Only the linear elastic analysis is emphasized. Presently the tensile force is ignored in concrete. In reality, concrete can take tension in between the cracks transmitted from the reinforcing bars due to the bond action ('Tension Stiffening'). Various reinforced concrete nonlinearities are considered such as tension stiffening, compression softening, shear transfer across the cracks from various literatures and are incorporated in the simulation tool based on finite element method. For this, uncracked concrete is modeled as elasto-plastic material and for cracked concrete smeared crack model is used because of its simplicity to consider in finite element analysis- Reinforcement is modeled as smeared along the element. Finite element methods are used for numerical analysis with eight node isoparametric quadrilateral elements. Nonlinear solution is done by modified Newton-Raphson method.

In this thesis, an attempt has been made to simulate a monotonically loaded RC beam with the main reinforcement only. For this three beams under different curing conditions were considered i.e. twenty eight days water cured beam, Seven days water cured beam and dry cured beam. The load deflection relationships, deformational shape and crack pattern in the experiment are also simulated in the computer. The result of the simulation is verified with the experimental results and are found in conformity. One of the major findings of the study is the behavior of the beam failed in flexure can be predicted more accurately than that of the beam failed in shear.

Thesis Title: **SEISMIC RISK ANALYSIS OF LUBHU AREA**

Submitted by: **Kishore Mohan Shrestha**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT:

Sand is used in concrete construction for two purposes - as a standard material to prepare mortar in order to identify the strength of cement, and as a constituent material for concrete production. So far, in Nepal, standard sand *used* to identify cement strength, is imported from India. Its actual need for testing of cement as a quality evaluation process is in the range of 1440 metric tons, which costs approximately NRs. 14 crore 40 lacs. Similarly, studies with regards to the qualities of various sands are insufficient.

This is a research study dedicated towards developing standard sand in Nepal as well as identify the potential sand reserves and properties of sand from those reserves to he used in Kathmandu.

Various sands have been collected and analyzed for both of the purposes, In the study, results of the proposed standard sands are compared with that of Indian Standard sand. Furthermore, properties of local sands *as* constituent materials are compared with that of proposed standard sand. The studied parameters are physical and chemical properties, strength and durability. It has

been observed that Karra and Chure sands from Hetauda are good enough in terms of quality and reserves to be used as standard sand. Similarly, two sources of river sands - Manahiira and Sangia Khola sand and one source of quarry sand - Belkhu are found good enough in terms of qualities and quantities for concrete consumption in Kathmandu valley.

Graduation Year 2005

Thesis Title: **RESPONSE OF LOAD BEARING BRICK MASONRY - EXPERIMENT AND NUMERICAL SIMULATION**

Submitted by: **Rudra Pun**

Supervisor: **Dr. Mohan Prasad Aryal, Dr. Roshan Tuladhar**

ABSTRACT:

The behaviors of brick masonry are governed by many factors such as the properties of the constituents and their interactions, manufacturing process and constructional practices which vary from place to place. Available data regarding the properties of brick, mortar, and brickwork in our local context are scaree. Experimental and numerical studies of brick, mortar and brickwork have been carried out in this thesis work. The particle size distribution and moisture content of sand were observed. For the preparation of me mortars of different grades, proportion by weight was adopted. Both hand made and machine made bricks were tested for water absorptions, compressive strengths and flexural strengths. The compressive strengths and flexural strengths of mortars were determined. Similarly to observe the behaviors of brickworks the compressive strengths, shear

strengths with and without pre-compression, direct and flexural tensile strengths in parallel and perpendicular to the bed joint were investigated. Load deformation curves in shear strength test and in prism test were recorded. The data obtained from the experiments have been compared with the results obtained in previous works and available in literatures.

A new numerical approach for the initiation and progressive crack propagation has been introduced for the brickwork- In this approach, continuous displacement functions are used until the occurrence of fracture. Fracture is considered to be evolved along the edge of the element. After the fracture, fractured edge is changed into the traction free or specified traction boundaries, thus introducing the elegant way of consideration of discontinuous displacement functions. This method has revealed realistic results regarding the behavior of cracks. If more refinements in the material properties could be introduced, it would certainly simulate more exact results. In this thesis, only in-plane loadings have been incorporated in the model and dealt as a plane stress problem. However, new numerical approach is applicable for all the possible combination of the variations of the loads and fracture modes.

Thesis Title: **MODEL STUDY ON BRICKMASONRY -INFILL REINFORCED CONCRETE FRAME**

Submitted by: **Dilip Raj Kandel**

Supervisor: **Mr. Prajwal Lal Pradhan and Dr. Roshan Tuladhar**

ABSTRACT:

This study is a small effort in the direction of preparing an analytical model to aid in the development of an appropriate design provision incorporating the effect of partially-infill brick-masonry wall in the reinforced concrete frame structures. The main objective of the study is to get the experimental behavior of the physical model and the analytical behavior especially in the static lateral load cases. A suitable geometric model is proposed which may be effective to represent thru the finite element approach.

To find the real behavior of the partially infill RC frame subjected to lateral load, a laboratory setup is made with one third down scale models. To observe the infill stress in different locations, the electrical strain gauge is attached. The change in the electrical resistance indicates that the strain develops in the infill-frame. When excessive change is noticed, at the same time, the failure of masonry is observed. The strain gauge at the comer

sides of the beam and column are not seem to be activated while cracks are already occurs at the adjacent of the opening. This shows that tensile failure occurs in the infill before the compressive failure takes place.

Exclusion of infill in design and analysis practice is due to the complex behavior of the infill material and the composite behavior of it. A simple diagonal strut model is chosen and with the basis of laboratory investigation new geometric parameters are developed. The new effective width of the pin-Joint diagonal strut is given. This is found to be very applicable in representing a bar element which can be easily analyzed through finite element method. The well known versatile program SAP2000 is used in the analysis. In the case of the central opening, the new parameters are developed for pin-joined diagonal strut; several cases are developed on it. These cases analyzed separately and a single strut model is proposed which gives the effective width of strut in any percent of opening. The validation of proposed model is made with the experiment on load-deflection.

Thesis Title: CONCRETE STRENGTH EVALUATION ON INTEGRATE QUANTITATIVE APPROACH

Submitted by: Arjun Marasini

Supervisor: Dr. Mohan Prasad Aryal

ABSTRACT:

Concrete strength, a widely used parameter in the design of Civil Engineering practice, depends upon its constituents' properties, methods of production and maturity. Strength of concrete is mostly determined from experiments, where individual effect of the multi-variables is not distinctly observed. There are efforts to express cement and concrete models in mathematical terms to reflect the effect of various parameters. But mostly they are confined to limited or single variable, and can not replicate various affecting aspects in an integrated manner, The present study is focused towards developing such model in multi-variable terms considering five influencing parameters: i) cement type within the range of Ordinary Portland Cement, ii) cement content, iii) water-cement ratio (w/*c*), iv) coarse aggregate size, and v) curing temperature. Among the adopted variables, w/c and cement content are expressed in the form of continuous functions, whereas cement composition in terms of compound compositions and fineness, aggregate size and curing temperature are expressed in discrete functions. Proposed

analytical models of cement and concrete were tested with experimental data. Parts of the experimental data were collected from literatures and used, whereas others were obtained from experiments conducted by the author. The proposed relationships reflect the cement and concrete strength within 5 - 10% of error in average. Proposed relationships will be helpful not only to evaluate the cement and concrete strength without laboratory testing but also to reflect the effect of multivariable through integrated relationships. A computer software has also been developed to calculate the effects of variables using the proposed models.

Thesis Title: **SEISMIC RESPONSE OF TWO ADJACENT & BUILDING "STRUCTURAL POUNDING"**

Submitted by: **Pawan Raj Maskey**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT:

Interaction between insufficient separated structures with different dynamics properties have been reportedly observed during ground motions. This phenomenon, often referred as earthquake induced structural pounding, may lead to some minor damage at the contact locations in case of moderate ground motions and may results in substantial destruction or even collapse of interacting structure during severe- The problem of earthquake induced pounding has been studied with the use of different model, FEM model of actual 9 storey building and adjacent 6 storey building with no separation gap is analyze to study response behavior. Building chosen for study has difference in story height. Only major direction is taken into account for calculating pounding force and displacement. For lateral load Response Spectra is taken from IS 1893(Part I): 2002 "Criteria for Earthquake Resistant Design Of structures" have been used. Pounding have been studied case by case basis with different mode displacement.

Main aim of this paper to determine the impact force for different modes. The results of the study shows FEM model for earthquake induced pounding obtained. Incase of different geometry, contact surface and material extensive experiment studies are required

Thesis Title: **SEISMIC RESPONSE OF HISTORICAL BUILDINGS**

Submitted by: **Smriti Shertha (Shakya)**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT:

Seismic response of 55 windows palace located in Bhaktapur Durbar Square of Kathmandu valley has been studied in this researeh. The 55 windows palace represents majority of historical structures in Kathmandu valley that were constructed during the medieval period and requires conservation and strengthening. Response of the existing palace has been first studied. Results from this study show shortcomings in the existing structure. Based on these shortcomings and conservation plans, strengthening and improvements were incorporated in a new model. Results from this new model show considerable improvement in stiffness and response of the structure as a whole.

Thesis Title: NON-LINEAR BEHAVIOUR OF COUPLED BOLTED WELDED JOINT OF RAPTI Bridge

Submitted by: Radha Krishna Mallik

Supervisor: Prof. Dr. Mohan Prasad Aryal

ABSTRACT:

This is the researeh about the response of coupled joint of steel truss bridge that was failed by buckling of gusset plate prier to rectification. As per the literature bolt and welding can be applied for the slip critical joint .In case of snug lightened bolted joint, welding can be applied after bolting connection carries some load for which it is in under stressed condition. Rapti bridge was also initially of bolted connection up to dead load limit and then welding was done as a stage construction. The classical approach is first used to prove the causes of buckling failure followed by the finite element method to develop four models of small pieces of joint to evaluate the response of stage constructed coupled connection. Effect of geometric as well as material nonlinearity and contact between bolt and bolt hole is considered to obtain the stress distribution in the vicinity of bolted and welded connections; at dead and live loads. This stress distribution is then evaluated to draw several realistic conclusions.

Thesis Title: **INTERACTION BETWEEN RC FRAMES AND BRICK MASONRY INFILL WALL**

Submitted by: **Sumat Shrestha**

Supervisor: **Mr. Prajwal Lal Pradhan**

ABSTRACT:

This researeh highlights on INTERACTION BETWEEN RC FRAMES & BRICK MASONRY INFILL WALL under lateral loading. Experimental and analytical studies have been carried out to investigate the performance of masonry infilled RC frame under in-plane lateral loading. Tests on four models of reinforced concrete Frames with brick masonry infill have been conducted to establish the load-deflection envelope curve; various parameters such as separation of infill from frame, stiffness of frames have been investigated.

The experimental models include RC frame with brick masonry infill of different opening centrally. Deformation of the models at the various interval of load is recorded by dial gauge. The magnitude of the stress is measured by using strain gauge. The various responses such as crack patterns, separation, deflection etc are observed by visual inspection. The lateral load in all models is given by hydraulic machine and weighing balance with

pulley system- The responses obtained on different model were observed.

The RC frame with fully infilled brick masonry model gave good response against the lateral force. Brick masonry infilled plays dominating role against lateral loading. The numerical solutions are compared with experimental results. A satisfactory agreement is obtained. Equivalent diagonal strut is used to model the stiffness of the infill. The characteristics strength of the masonry plays the vital rote in the strength behaviour of the RC frame with infill- The separation of infill from frame increase in load, resulting in reduced load carrying capacity and stiffness. The completely infilled masonry wall increases the stiffness of the structure.

Thesis Title: SEISMIC HAZARD OF PASHUPATI DEVELOPMENT AREA

Submitted by: Indra Narayan Yadav

Supervisor: Prof. Dr. P. N. Maskey

ABSTRACT:

Pashupati Development area comprising 264 Hectares lies at the center of Kathmandu Valley. Due to most of buildings and structures of heritage value located, the area has been important from conservation value. Least damage was observed in the area during earthquakes including that of 1934 A.D. The Seismic hazard assessment of the area is an issue of national and international concern. Since a number of buildings and other infrastructures are increasing in the area and no systemic study on the seismic risk has been carried out, the present study attempts to fill the void. The seismic hazard analysis of Pashupati Development area is carried out by considering 10-active faults as earthquake sources surrounding the area, assuming Poisson's process of occurrence of earthquake. Using conditional Probability of magnitude of earthquake and source to site distance, the probabilistic seismic hazard curve at the bedrock is determined, basically using Cornell's method. The hazard curve is obtained using three empirical attenuation laws given by 'a' Youngs et al. (1997) 'b' Kawashima et al, (1984 & 1986) and 'c'

Cornell et al. (1979). The Hazard curve in the form of probability of exceedance per annum and in 50-years period at the bedrock and al the ground surface using all three empirical attenuation models are obtained. The result shows that the probability of exceedence from Cornell et. al. attenuation is lowest from Youngs et al. that is highest. The PGA al bedrock with 10% of probability of exceedence by using the attenuation law by Youngs et al. is 0.265g, Kawashima et. al. is 0.198g and Cornell et al. is 0.186 in per annum. In 50 years at 10% of probability of exeeedcnce are respectively 0.745g, 0.521g, and 0.495g in bedrock. One-dimensional wave propagation analysis is carried out to obtain the local soil effect considering linear, non-linear and equivalent linear properties of the soil. The amplification factor of 1.23 and 1.97 are obtained for nonlinear and linear behavior of soil using soil profile of Guheshwori, representing Pashupali Development area, whereas the equivalent linear modeling results into an amplification factor of 1.26, very close to that of non-linear. The amplification factors for Boudha area, in the vicinity for refere, are obtained as 1.30, 2.13 and 1.52 respectively. The hazard curve with probability of exceedence per annum is obtained for all cases. The time history at the surface of the Pashupati Development Area is obtained for design purpose considering the amplification factors and with due scaling according to 10% probability in 50 years based on Loma Prita Earthquake.

Thesis Title: **DEVELOPMENT OF DESIGN OF SINGLE LANE T-BEAM WITH FOOTPATH BY PROVIDING MINIMUM THREE DIAPHGRAMS AND THREE LONGITUDINAL GIRDERSFOR VARIOUS SPANS**

Submitted by: **Dinesh Kumar Yadav**

Supervisor: **Mr. Jagat Kumar Shrestha**

ABSTRACT:

The objective of proposed research is to develop the design practice for single lane T-beam bridges with footpath by providing minimum three diaphragms and three longitudinal girders for span up to 25.0m keeping other parameters namely depth of flange, web thickness, and breadth of flange and grade of Concrete/steel constant. The Standards Drawings for Road and Bridges prepared by Department of Roads for single lane T-beam bridges of spans 12.0m, 14.0, 16.0m, 18.0m, 20.0m 22.0m and 25.0m are taken and analyzed completely through three different analytical methods of deck analysis namely Courbon's Method, Method of Harmonic Analysis and Orthotropic Plate Theory for live load and dead load in order to assess the realistic and compatible values under worst conditions of loading.

Moreover, suitable modeling for each span of bridge deck is developed and analyzed using 3D frame element in SAP2000

software for dead load and live load. The results show that maximum compressive and tensile stresses developed due to worst conditions of loading are within permissible range without varying depth & breadth of flange, web thickness and steel/concrete grade for span up to 25.0m. Only marginal increase in depth of diaphragms and longitudinal girders are needed as span increases. The results of study also show in order to design T-beam bridges there is no need to provide five diaphragms as mentioned in Courbon's Method since this method overestimates the load on the exterior girders and Under-estimates the load on interior load during concentric loading. With the availability of more accurate methods like Method of Harmonic Analysis and Orthotropic Plate Theory, the Courbon's Method should be used for preliminary design of girder-sections only. It is found that output results obtained for moments, shear forces and deflection profiles from SAP2000 for ach span is very much close to above analytical methods. Therefore, in order to reduce rigorous hand amputation works SAP2000 can be used for the T-beam analysis.

Thesis Title: **STUDY ON THE COMPRESSIVE AND BOND STRENGTH OF CONCRETE SUBJECTED TO ELEVATED TEMPERATURES**

Submitted by: **Aman Prakash Malla**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT:

The performance of compressive and bond strength of concrete at elevated temperatures are critical especially in case of the evaluation of building behavior in fire situations. In case of Nepal particularly, elevated temperatures are observed in concrete kiln chimneys. In order to assess the performance of reinforced concrete members under such situation it is important to understand the changes in the concrete properties due to the temperature exposure.

In this study, the influence of elevated temperatures on the compressive and bond strength of concrete made from sandstone aggregates is experimentally investigated. The test parameters involved in this research are the exposure time (30, 90 and I8Ominutes), temperature (100, 200, 300°C) and depth of embedment (30 and 60mm) of the reinforcing sleet into the concrete. The effect of cement sand plaster on the compressive strength was also studied.

Test results indicated an increase in compressive strength for the 28 day concretes at elevated temperature, on the other hand a noticeable loss of bond strength of the 45 day concrete was observed. Results of the compressive strength of concrete with cement sand plaster surface suggested that a different technique be adopted than the one used in this research work.

Thesis Title: **SEISMIC CAPACITY OF BRICK MASONRY RESIDENTIAL BUILDING**

Submitted by: **Lisha Shrestha**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT:

Low-rise residential buildings constructed of unreinforced brick masonry with concrete slabs and tie beams at plinth and floor levels are very popular in developing countries. It is necessary to assess the seismic capacity of such structures so that they can be adopted safely in seismically vulnerable areas, as developing areas are the ones that are greatly affected during such disasters. Typical two and a half storied residential building representing the most popular housing types are considered in the study. The analysis is done by finite element method using eight-noded solid element. SAP 2000 software is used as the analysis tool. Seismic coefficient method is used for the seismic analysis. The performance of the building was checked based on the various stresses and drift of the building. The result of the study shows that the critical section is located around the openings and at the top and bottom at the junction. The critical section corresponded to tensile failure. Therefore the building needs to be strengthened at those locations.

Thesis Title: PRODUCTION OF VERY HIGH STRENGTH CONCRETE IN CONTEXT OF NEPAL

Submitted by: Krishna Man Shrestha

Supervisor: Prof. Dr. Mohan Prasad Aryal

ABSTRACT:

Very high strength concrete is a demand of modem construction especially in high rise structures, hydropower projects and other special structures. This thesis presents some data about the possibility of producing very high strength concrete in Nepal using local materials and admixtures available in the Nepalese market.

Coarse aggregate from Chapagaon, sand from Belkhu, OPC from Udayapur and admixture - super plasticizer (Super 100P) and micro-silica available in the market were used for the production of concrete. Experimental investigation was conducted in the laboratory of the Institute of Engineering, Pulchowk. The nominal maximum size of coarse aggregate was 12 mm and sand of size 150-600 micron were thoroughly washed and used in the mix. Existing mix design approaches not being applicable trial and error method was used to identify the quantity of individual constituents. Various combinations of constituents were used to arrive at the possible higher strength of the concrete. Altogether

83 combinations were used - three variations of *w/c*, three dosage of super-plasticizers and three dosage of micro-silica- Five specimens were used for one combination- Cube strength at 28 days was adopted to assess the concrete strength, the cube size being 100 mm.

Average compressive strength of different combinations obtained from 28 days test varied from 92-130 MPa. It was also observed that strength increases with increased dose of micro-silica and super plasticizer and decreased when the amount of water in the mix increased.

Graduation Year 2006

Thesis Title: **SELF COMPACTING CONCRETE FROM LOCAL MATERIAL IN NEPAL**

Submitted by: **Jhapper Singh Vishokarma**

Supervisor: **Prof. Dr. Mohan Prasad Aryal**

ABSTRACT:

Self compacting concrete (SCC) has three basic principles and requirements viz. filling ability, passing ability and segregation resistance. It is a demand of modem constructions specially where the durability concern is high and vibration consolidation is inaccessible or eliminated. The importance of this type of concrete is felt much when we require to cast thin structures, inaccessible shape-structures, and the structures where the reinforcement congestion is very high like a beam-column joint in high rise building and we require pump-able concrete. The thesis reports the development of SCC by using local materials i.e. OPC, 53 grade, Udaipur, crushed coarse aggregate (<12mm size-angular), Chapagaon, Belkhu sand-two sizes: (i) 600 micron to 6mm and (ii)150 micron to 600micron, micro-silica, Superplastisizer (superplast- pc) and fly ash (pozzocrete-63) available in the local market.

Mix design and proportioning of SCC mixes were based on guidelines given by Okamura and Ozawa and other relevant literatures. For the research, three w/c ratios (0.50, 0.54, & 0.58), six coarse aggregate to fine aggregate ratios (0.67, 0.69, 0.72, 0.82, 1.00 & 1.22) and three fine sand to coarse sand ratios (0.242, 0.245 0.250) were chosen. The adopted amount of cement was 300kg/m^3 and the weight of concrete - 2358kg/m^3 throughout the mixes. Altogether 133 nos. of combinations (mixes) were prepared to evaluate their behavior in fresh state in three different tests in quick succession. Cube strength at 28 days was adopted to assess the concrete strength, the cube size being 100mm, for some of the best mixes exhibiting the fresh properties of SCC.

Criteria selected for acceptance of the concrete mix as SCC were; i)slump value at slump flow test 650mm or higher, ii) blocking ratio at L- box test higher than 0.8 and iii) U- box index value (difference between levels of concrete in two compartments of U-box) in U box test not higher than 30mm. In Slump flow test, the acceptable time limit for SCC to flow 50cm diameter circle was 2 to 5 seconds. The properties of SCC in fresh and hardened states were found out. Among the trail mixes, some mixes exhibiting self compacting concrete properties, having 28 day- compressive strength of around 40Mpa, were obtained, SCC mix in w/c = 0.58 was found to be the best in fresh properties than in other two w/c ratios while the higher strength was observed in w/c ratio = 0.54.

Thesis Title: **DEVELOPMENT OF FERRO FIBRO CONCRETE MANHOLE COVER**

Submitted by: **Kamal K. C.**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT:

Ferro-Fibro Concrete is a form of thin concrete reinforced with layers of continuous and relatively small diameter mesh wire each coated with a thin layer of fiber cement concrete. Manhole Covers are round, rectangular, square or triangular in shape, generally made of Cast iron which keep passenger-by from falling and allow to reach the manhole so that the people can clean, inspect or repair the sub surface utilities. The cast iron manhole covers are found to be heavy, expensive and more probable to theft problem. So, it is necessary to think about alternative material of manufacturing manhole covers; such as Ferro-Fibro Concrete.

In this study, the best concrete mix proportion *is* chosen to get the compressive strength M 30 to be used for casting Ferro-Fibro Concrete Manhole Cover. The use of single and double layer wire mesh, optimum use of fiber and sufficient workability to gain by admixture were considered during the casting procedure. Mortar, Compressive, Flexure and Splitting test were conducted

on both Plain Cement Concrete and Fiber Reinforced Concrete along with tensile strength test of wire mesh. The best suited mix proportion was found from above tests for casting Manhole Cover and Punching test was carried out on 28 days with both single layer and double layer wire mesh.

The result of punching test carried out on the double wire Manhole Cover was successful for maximum IR.C Class AA Loading with F.O.S. being 1.25, and satisfactory as per NS 104/2042 with F.O.S. 1.57.

The economic analysis and the satisfactory result of the performed tests shows that the Capabilities of Ferro-Fibro Concrete in the Engineering field cannot be under estimated and further exploration in such a field will definitely lead to fulfillment of needs and desires of various clients.

Thesis Title: **RECTIFICATION OF QUASI RC AND MASONRY BUILDING**

Submitted by: **Nashila Shrestha**

Supervisor: **Mr. Prajwal Lal Pradhan**

ABSTRACT:

Quasi Buildings having mixed structural components like old or new storey either RC or Masonry types are found in significant number mostly in core areas of Kathmandu Valley. The construction practice of residence building in Kathmandu is without proper design guideline. Quasi buildings also fall in the category of such a poor practice. Due to their significant number in the main valley, it is found necessary to find out the exact performance to know what types of quasi structures are greatly influenced during lateral vibration. The present study proposes two dimension structural models of new and quasi structures. Finite element analysis has been carried out using analytical software SAP 2000- The individual brick and mortar has been modelled as shell element with degree of magnification of 2.5.

Based on the analytical output, various parameters like lateral displacement, maximum drift, stiffness and capacity in terms of expected failure load have been found out for each type of structure. These parameters of quasi structure have been

compared with the parameters of new structure of same type. The comparison resulted in capacity reduction factor and strength degradation factor. They are helpful to check the performance of quasi structures during lateral vibration. Thereby it can be known which type of quasi structure can be strengthened by different retrofitting techniques to perform well in future earthquake.

Thesis Title: PERFORMANCE OF BRICK INFILLED RC FRAME BY FERRO CEMENT JACKETTING

Submitted by: Liva Shrestha

Supervisor: Mr. Prajwal Lal Pradhan

ABSTRACT:

The structural behavior of brick-masonry infilled reinforced concrete frame system, using ferrocement jacketing, are investigated. Ten specimens which included five specimens without ferrocement jacketing and five specimens strengthened by ferrocement jacketing are cast and tested for their structural performance. This research studied brick masonry infill with five different percentages of openings viz.0%, 30%, 60%, 90% and 100%. This study proposes the pattern of applying ferrocement jacketing by double form layers. Owing to financial and technical constraints, small-scale models of 1:3 reduced sizes was constructed and tested under horizontal lateral force. The first crack loads, ultimate loads are experimentally obtained and compared with the brick-masonry infilled reinforced concrete frame system without ferrocement jacketing. The compression and tension zone of the structural system with ferrocement jacketing observed experimentally is used to calculate the thickness of the strut from the theoretical strut model calculation

methods and again compared with that obtained for the structural system without ferrocement jacketing.

The test results showed that strengthening of the brick-masonry infilled reinforced concrete frame system by using ferrocement jacketing increased the first crack and ultimate loads of the composite system. The double form layer ferrocement jacketing system resulted in a significant increase in the load carrying capacity of the composite system. It is recommended that the strengthening of the brick-masonry infilled reinforced concrete frame system by using double form layer ferrocement jacketing be adopted in practice due to the superior behavior of the composite system-

Thesis Title: **SEISMIC PERFORMANCE OF MASONRY BUILDING WITH TIMBER FRAMES**

Submitted by: **Kabir Shakya**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT:

Nepali traditional dwelling houses constructed in brick masonry with traditional technology constitute the major type of structures in the urban nuclei of the Kathmandu Valley. Preservation of these structures against possible earthquakes is of prime concern in view of conservation needs. The present study deals with the seismic evaluation of typical traditional building of brick masonry with timber frames.

The present work of the comprehensive study on the subject is divided into two parts. In the first part, various modeling of connections between different elements of brickwork and timber is studied through analysis of number of analytical test models. Based on the results of the sensitivity study of different joint models, the most efficient and appropriate model adopted in the seismic evaluation of the typical traditional dwelling house, the second part of the work. The seismic evaluation of the typical building is carried out by three dimensional analysis of the structure using finite element method. For the analysis, the

brickwork is discretized as the eight nodded solid elements, and the timber beams and columns as frame elements. The flexible timber floor is duly considered. The building is assessed for various load cases including gravity loads and earthquake effects in terms of response spectra.

The results of the analysis show that the traditional floors and the spandrels of the existing structure are the weakest parts which need strengthening to make the structure withstand earthquake excitation. The required improvement and strengthening techniques are proposed mainly with the floor converted into rigid floor diaphragm. The analysis of the modified structure shows considerable improvement in the dynamic characteristics of the building and overall structural response.

Graduation Year 2007

Thesis Title: BEHAVIOUR OF ECCENTRICALLY LOADED ISOLATED SPREAD FOOTINGS UNDER EARTHQUAKE

Submitted by: Amrit Ratna Tuladhar

Supervisor: Dr. Roshan Tuladhar

ABSTRACT

In Kathmandu valley, mostly in core city areas, most of the buildings are constructed attached to each other; placing columns at the property line. In such buildings, if the isolated spread fooling system is adopted then the columns lying at the property line invariably transfer axial load through one sided fooling; as the base slab of footing can't be extended beyond the property line.

Various literatures recommend the necessity of combined footings in such case. Nevertheless, the prevailing construction practice is such that such eccentric footings are constructed usually without the provision to counteract this eccentricity.

The major objective of this research work was to assess the vulnerability of this type of footing under the earthquake taking into account the effect of supporting tie beams at plinth level and

brick masonry walls under it in two soils types; soft and stiff. Soil parameters considered were that of "organic" and "sandy gravel" representing soft and stiff soil types respectively. It aimed to study the response of such footings in terms of displacements and stresses generated within the supporting soil mass and its structural components.

Finite element modeling tool has been used for the modeling purpose of the concerned footing in SAP 2000 (ver 8.0). An existing building that best represents the prevailing construction practice has been considered. For this purpose- Eight-noded solid element with three translational degrees of freedom per node has been used as a discrete element. Soil Structure interaction has been incorporated in detail taking into account of its intrinsic non-linear behavior with multilinear link elements at the fooling base. Spring constants for these link elements were computed based on "elastic half space theory". Load deformation curve of the foundation has been modeled as the "elastic-strain hardening plastic" model to account foundation non-linearity. Also, in order to allow the variability in soil parameters, lower and upper bound solution approaches have been carried out with a wide range of factor "four" In between.

It has been observed that such footings arc totally unsafe in case of "organic soil" that greatly exceeded the ultimate displacement capacity corresponding lo lower bound solution approach both in gravity and earthquake load cases. Also solution corresponding to upper bound solution in same soil type has shown that such foundation remained within elastic limit in case of gravity loading. Whereas in an upper bound approach in earthquake loading, foundation exceeded its elastic limit but remained well below its ultimate capacity.

Likewise, footings on "sandy gravel" soil corresponding to both the solution approaches were found below the elastic limit under the gravity loading. Whereas same was found at the verge of yielding in case of earthquake loading corresponding to lower bound solution; but remained below -the elastic limit in upper bound approach.

Also tendency of lifting up of the free edge of such footing was found greater in case of footing resting on stiff soils as "sandy gravel". No such phenomenon was observed in soft soils as "organic soil".

Thesis Title: **OUT OF PLANE SEISMIC RESPONSE OF INFILL BRICK MASONRY WALL**

Submitted by: **Krishna Raj Pantha**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT

Significance of RC bands in preventing failure of infill wall especially in out of plane direction was investigated. Also the change on magnitude of various stress components on bounding RC frames due to presence of RC bands was examined. Two types of models viz. the infill walls with and without RC bands were prepared and studied numerically to get comparative results. Micro modeling i.e. eight nodded solid element for bricks, non-linear link elements for mortar and solid elements with sufficient subdivisions for bounding RC frame was carried out for one focused infill panel and macro modeling i.e. equivalent diagonal strut modeling for infill walls and single solid element for bounding RC frames was carried out for the infill walls except the focused infill panel. Non linear direct integration time history analysis was carried out for the both types of models. Only the output results of focused infill panel was studied for both types of models.

It was found that the presence of RC bands reduces the tendency of failure of infill wall especially in out of plane direction. It was concluded by studying the stresses on bricks, displacement of bricks and stresses on mortar. The probable crack propagation was plotted after studying the stresses on mortar determined from forces on link elements. Sufficient cracks were seen on wall without RC bands and fewer cracks were seen on walls with RC bands. The magnitude of maximum stresses on bounding frames i.e. beams and columns were found more in model without RC bands than in model with RC bands. But in model with RC bands, the stresses on the column at band column junction were significantly large in comparison with the stresses on the column at same location in model without RC bands. Hence except the stresses on band column junction overall responses for the mode! with RC bands were less in magnitude in comparison to the model without RC bands and therefore the provision of RC bands on infill wall was found beneficial if due care is given at band column junction.

Thesis Title: STRUCTURAL PERFORMANCE OF REINFORCED CONCRETE BEAMS REINFORCED WITH TMT BARS

Submitted by: Sidhartha Sagar Shrestha

Supervisor: Dr. Roshan Tuladhar

ABSTRACT

TMT (Thermo Mechanically Treated) rebar has been in use in Nepal for last couple of years. There has been a state of confusion among designers to go into TMT or still use CTD (Cold Twisted Deformed) bars. It is the right time to investigate the comparative performance of TMT reinforced structural member and compare its performance to similar CTD counterpart. In this research work, eight reinforced concrete beams of size: 2000mm x 230mm x 300mm. Four of them were reinforced with TMT bars from local market and the other four with CTD bars. The reinforcement detail in all the beams are identical including shear reinforcement; except four had TMT and other four had CTD longitudinal bars- Out of four in each case, two were tested in monotonic loading and the other two were tested in cyclic loading using Universal Testing Machine. The crack propagation pattern in all the eight beams was almost similar. The load deflection curve showed clear system yielding in case of TMT where as it was having smooth path in case of

CTD. All the beams showed failure mode as crushing of concrete as designed except one which failed in shear. It was noted that the ratio of deflection of the centre point of the beam at the crushing load to that at the yielding load were more or less similar for both TMT and CTD reinforced beam. TMT reinforced beams showed greater ultimate load which was due to its higher strength. In both the TMT and CTD reinforced beams, the monotonically loaded beams showed greater ultimate load than the corresponding cyclically loaded beam. This investigation showed that the TMT reinforced structural beams behave more or less similar structural performance up to the rupture of tension reinforcement.

Thesis Title: **SEISMIC VULNERABILITY OF PLANT SLAB STRUCTURES**

Submitted by: **Kshitij Charana Shrestha**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

The effectiveness of Hat slab construction is very well known, however its vulnerability when subjected to seismic excitation also needs to be studied owing to its flexibility. Flat slab buildings though prove to take gravity loads effectively, their performance under earthquake excitation has always been in question. For the study purpose, a 5-storey regular building has been taken. For the modeling of flat slab, an effective beam width concept has been incorporated where the portion of the slab that participates in stiffness sharing is formulated. The analytical procedure to be followed for the analysis procedure has been linear static method. Here the vertical distribution of base shear to different floor levels has been done in accordance with the Indian Standard IS 1893 (Part 1): 2002. The seismic performance of the given building model for flat slab system as well as for the corresponding conventional slab-beam-column system has been studied. The check for limit states for inter-storey drifts as well as punching shear has been done. Comparison has been for the exceedence of the above mentioned

limits states for the two systems. Flat slab buildings are found to show higher inter-storey drift values as compared to those shown by conventional framed system. Cost analysis has been performed for the two systems taking into consideration the different parameters: quantity of concrete volume, reinforcement, formwork, total volume of building and the time scale factor. The total cost involved in construction for the two systems is compared for different configurations of building to stale the effectiveness of flat slab building over the conventional beam-slab-column system. Flat slab system is found to be cost effective for panel size ranging upto 6m x 6m and not so much effective afterwards.

Thesis Title: **EFFECTIVENESS OF OVERHEAD TANK AS TUNED LIQUID DAMPER**

Submitted by: **Preju Rajbhandari**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

Tuned liquid damper has been very effective form of structural control device. Its working principle is same as tuned mass damper .The only difference is that the mass is replaced by liquid specially water. It dissipates vibration energy through sloshing. For high rise building the tuned mass damper and tuned liquid damper are very effective energy dissipating device.

Overhead water tank of a considerable capacity is needed for services of a public building. It is envisaged that such a large overhead tank if located and designed properly could act as an effective damping device. With this view present study is carried out to study the effectiveness of tuned liquid damper in a typical five storied public building prevalent in Nepal. By tuning the sloshing frequency with the fundamental frequency of the building, the configuration of tuned liquid damper has been determined. The tuned liquid damper has been modeled by using spring mass model. Response spectrum IS1893:2000 has been used for dynamic analysis. The building with empty overhead

tank is analyzed to get the displacement of building. The building with tuned liquid damper is again analyzed and the displacement without tuned liquid damper and with tuned liquid damper is compared. From the study it is concluded that for a configuration of tuned liquid damper the reduction in displacement of the building decreases as the mass ratio and depth ratio increases. When the reduction in displacement is compared between two configurations of tuned liquid damper for same depth ratio, the larger sized tuned liquid damper is found to be more effective.

Thesis Title: **THE EFFECT OF AMBIENT AIR TEMPERATURE ON STRIPPING TIME OF FORMWORK OF REINFORCED CEMENT CONCRETE STRUCTURES**

Submitted by: **Siddharth Shankar**

Supervisor: **Prof. Dr. Mohan Prasad Aryal**

ABSTRACT

Determination of the removal time of the formwork is one of the major aspects in concrete construction. The maturity method is a technique for predicting concrete strength based on which formwork removal time is identified. In this thesis work the three steps adopted to identify the maturity of concrete and so evaluate the time for the formwork removal are; i) establishment of strength- maturity relationship for the adopted concrete mix; 2) strength identification of adopted concrete mix at specific temperature and age, and 3) verification of the strength-maturity rule.

The experiment was conducted in concrete cubes with two different types of cement -Ordinary Portland Cement - from three different groups, and Portland Pozzolana Cement -from two different groups. Coarse aggregate and sand were used from Chapagaun and Belkhu. The nominal maximum size of coarse

aggregates was 20mm and the concrete mixex were 1 :2 : 4 ; 0.5 & 1 : 1.5 : 3 : 0.5. Testing of the specimens was carried out at different ages ranging from 1 day to 56 days and the curing temperature also varied from 5°C to 45°C. The experimental investigation was conducted in the laboratory Institute of Engineering, Pulchowk Campus.

Based on various literatures it has been assumed that 70% of design strength of concrete is reasonable to remove the formwork especially from the bottom of the bending members. This aspect has been used in this thesis to arrive at the maturity of concrete at different temperatures reflecting various regions of Nepal. It has been observed that the stripping time of formwork for horizontal member such as beams and slabs varies from 2 days to 117 days depending on temperatures ranging from 45 ° C to 0 ° C and cement type - OPC or PPC. The stripping time of formwork for vertical member such as column and sides of beams varies from 12 hours to 6 days depending on temperatures also ranging from 45°C to O'C and cement type - OPC and PPC, assuming that the formwork can be removed if no cracks are formed at the comers of the specimen during de-moulding or formwork removal. It was also observed that increase in cement content shortens the stripping time of formwork.

Relationship between splitting tensile and compressive strengths of concrete has also been developed with the adopted types of specimen.

Graduation Year 2008

Thesis Title: DECOUPLED SEISMIC DEFORMATION ANALYSIS OF A ZONED ROCKFILL DAM

Submitted by: Shanker Dhakal

Supervisor: Prof. Prajwal Lal Pradhan

ABSTRACT

The seismic safety, in terms of crest settlement, of a zoned rockfill dam designed by the traditional empirical methods is evaluated. The proposed high dam of Bagmati Multipurpose Project (BMP), Nepal is taken as a typical case.

2D finite element method with plane strain assumption is used. The 'decoupled deformation analysis' technique is adopted in which the peak crest acceleration response obtained by dynamic analysis is utilized to predict the potential permanent settlement of the crest using the chart developed based on Newmark's analysis procedures. All calculations are performed on a PC using the available SAP2000 software package. The recorded N-S and the vertical acceleration components of the famous Imperial Valley earthquake of May 18, 1940 (El Centro, California, USA) are taken as the prescribed input ground motion. Linear direct integration time history analysis based on

Wilson- θ (θ = 1.42) incremental algorithm is adopted. Damping is introduced in terms of Rayleigh's damping coefficients. Four different finite element models: rigid and flexible foundation models, each with and without reservoir; designated by RF_WOR, FF_WOR, RF_WR and FF_WR are evaluated. For the models with flexible foundation, the effective part of foundation to be taken in the model is worked out by trial procedure based on 'stress criterion'. For calculating the hydrodynamic effects in the case of the models with reservoir and also for the chart to predict the potential permanent settlement of the crest, the IS guidelines is simply followed.

A great deal of parametric studies on free vibration analysis and initial static deformation analysis are carried out. The results of the parametric studies compare well with the classical soil mechanics and the findings of the previous researches reviewed in this thesis, thereby justifying the models exercised. It is revealed that the permanent crest settlement of the BMP dam predicted with the four different models is relatively higher.

Graduation Year 2009

Thesis Title: **EFFECT OF NEAR FIELD VERTICAL ACCELERATION ON SEISMIC RESPONSE OF LONG SPAN CABLE STAYED BRIDGE**

Submitted by: **Bipin Shrestha**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT

Measurement of ground motion during the recent earthquakes indicates that the vertical acceleration can reach values comparable to horizontal acceleration or may even exceed these accelerations. Also field observation proved that many structures and bridges experience significant damage attributable to high vertical forces. The unique high amplitude and short to medium duration pulse that is a common characteristic of near fault ground motions caused due to the Forward directivity has generated attention due to the severity of damage these motions have caused in densely populated urban environments. A full 3-D model capable of representing the features of the Karnali cable- stayed bridge was developed to find out effect of above mentioned ground motion on long span cable-stayed bridge. Modal analysis of the cable-stayed bridge was performed to

determine the natural response. Four different types of modes were observed namely; Deck lateral bending and torsion modes, Deck vertical bending mode, Cable local modes and Tower and pier dominated modes. Sensitivity analyses were performed to identify the influence of cable local vibration and modulus of elasticity on global modes of vibration.

Linear modal time history analysis was performed; five different ground motions were used to study the seismic responses which were applied in two stages. In stage I only horizontal components (H only) were applied and in stage II horizontal and vertical components (H+V) were applied simultaneously. Nonlinear direct time integration analysis considering the large displacements yielded nearly similar responses which validates the linear modal analysis. Two parameters Amplification factor (AF) and Final Amplification factor (FAF) were used to study the influence of vertical acceleration. Linear regression analysis was carried out to identify the ground motion characteristics that adversely affect the structural response. Comparison of the responses of Tower base of the cable-stayed bridge was made for Forward directivity ground motion with Non Forward directivity ground motion. Analysis was carried out to find out whether the stay cables and pylon be able to resist the demand within elastic range.

The results indicate that the vertical ground motion will have non-negligible effect on the axial response of the cable and tower of the cable-stayed bridge, it is identified that forward directivity ground motion could have damaging effect when velocity pulses are tuned with natural period of the Steel tower of the bridge.

Thesis Title: **EFFECT OF RUBBER AGGREGATE ON MECHANICAL PROPERTIES OF CONCRETE**

Submitted by: **Devendra Prasad Sah**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT

This work on "Effect of Rubber Aggregate on Mechanical Properties of concrete" comprises a thesis undertaken to partially fulfill the requirement of the Master Degree course in Structural Engineering at IOE, Pulchowk Campus (T.U.).

The rubberized concrete has high toughness, durability, sound insulation and energy absorption in order to reduce damage in case of stroke, but lower value of compressive and tensile strength. The aim of this research work was to study the effect of content of rubber aggregate on mechanical properties of concrete for its application on structural and nonstructural members. Two types of cement OPC and PPC are being used separately with rubber aggregate and its effect on strength was also observed. The plain rubber aggregate was coated with cement paste and an experiment was carried out to study its effect on mechanical properties of concrete.

This report presents the Unit Weight, Workability and Strength (Compressive, Tensile and Flexural) Properties of concrete containing 0%, 10%, 25% and 40% of rubber aggregate by volume as a replacement of mineral aggregate. The primary data obtained from material test results was considered for mix design of laboratory test specimens. Cubes were tested under direct compression and Cylinders & Beams were tested under indirect tension to study the effect.

The study shows that the rubberized concrete can be finished closed to the same standard as plain concrete with some additional effort. However, workability in the mix is reduced while increasing the content of rubber aggregate. Coating the rubber aggregate increases the workability. The unit weight of rubberized concrete is found to be decreased but still higher than the value of light-weight concrete. The result shows that the incorporation of rubber aggregate into concrete mixes produces a significant reduction in compressive and tensile strength of concrete. The result shows a beneficial effect regarding the flexural strength at lower content of rubber aggregate. It is observed that coating the rubber aggregate with cement paste reduces the percentage reduction of strength and have some better results.

A rigorous study of previous research work shows that the rubberized concrete has better capacity in absorbing significant plastic energy and withstanding large deformation, high resistance to Impact, improved durability, and improved acoustic and thermal insulation. The current study shows that the use of rubber aggregate is limited to 10% by volume of mineral aggregate to prevent too great loss in mechanical properties of concrete. It is finally concluded that the rubberized concrete containing 10% rubber aggregate can be used at least in non-primary structures such as road and bridge barriers, wall panels (concrete block).

Thesis Title: ANALYTICAL STUDY OF INFILL BRICK MASONRY WALL WITH OPENING UNDER IN-PLANE LATERAL LOAD

Submitted by: Jibendra Misra

Supervisor: Dr. Prajwal Lal Pradhan

ABSTRACT

The effort of this research is focused on the study of brick masonry wall in reinforced concrete frame structure. The main objective of the study is to get the analytical behavior of models in static lateral load case. Five samples of infill frame and three samples of masonry panel wall without RC frame were prepared and studied numerically under lateral static load. The effect of opening size and stiffness of infill relative to the frame were studied in terms of lateral stiffness, rotational stiffness etc. It is observed that effect of opening size have large influence on the overall response of infill. The lateral stiffness of masonry panel is drastically improved if it bounded by reinforced concrete frame.

Thesis Title: **BOND STRENGTH OF SELF COMPACTING CONCRETE AND NORMAL CONCRETE UNDER CYCLIC TEMPERATURE**

Submitted by: **Krishna Singh Basnet**

Supervisor: **Jagat Kumar Shrestha**

ABSTRACT

Reinforced concrete structures are expected to be of higher quality and strength. One of the effective means to achieve this in Nepal, instead of using Normal concrete need to be explored self compacting concrete and predict the value of bond strength at joints and connections. The aim of this research is to experimentally investigate Bond strength of self compacting concrete and normal concrete under cyclic exposure time and elevated temperature load compare with normal concrete.

A total of two phases of experiments have been conducted. They were Phase I cube specimens and Phase II beam specimens. Phase I, sub-divided into two types of experiments A and B. Experiments A was investigated as a specimen's, preliminary study of time development of material properties bond strength of self compacting concrete, self compacting concrete with mix design of 0.02 silica fume (by volume of cement) and normal

concrete wet curing after at 3 days, 7 days, 14 days and 28 days. Experiments B was studied bond strength of self compacting concrete and normal concrete under cyclic exposure time and elevated temperature. The test parameters involved in this research were the exposure time (30 min, 90 min, and 180 min), temperature (100°C, 200°C and 240°C) and depth of embedment (25mm, 50mm and 100 mm) of the reinforcement steel Fe415 .Phase II, Experiments-C, Beam splices of self compacting concrete and reference beam of normal concrete were cast and tested through wet curing after 28days.The studies was predicted preliminary study of load carrying capacities (cracking and ultimate load at lap-splices of 520mm, 260mm and 130mm -8 dia steel Fe 415), mode of failure, cracking behavior and flexural bond strength of concrete beams.

Thesis Title: **ANALYTICAL STUDY OF FLEXURAL STRENGTHENING OF REINFORCED CONCRETE BEAMS BY USING EXTERNALLY BONDED CFRP SHEETS**

Submitted by: **Rabindra Kumar Sharma**

Supervisor: **Bishnu Prasad Gautam**

ABSTRACT

Externally bonding carbon fiber reinforced polymer (CFRP) sheets with an epoxy resin is an effective technique for strengthening and repairing reinforced concrete (RC) beams under monotonic loads. In this study, three types of beam were adopted. They are Laboratory scale Beam (4000x150x300 mm), Building Specific Beam (5000x300x450 mm) & Bridge Specific Beam (20000x500x1800 mm). A total of seventy eight RC beams were analyzed. For the study of effective percentage of CFRP, six control beams, eighteen beams reinforced with 0.17% to 1.0% CFRP corresponding to 0.33% rebar and eighteen beams reinforced with 0.17% to 1.0% CFRP corresponding to 0.75% rebar are analyzed. For the study of effect of offset of CFRP from support, twenty seven beams with 0% to 40% offset of CFRP from support corresponding to 0.5% CFRP & 0.33% rebar and nine beams with 0% to 40% offset of CFRP from support corresponding to 0.17% CFRP & 0.75% rebar on Laboratory

scale beam are analyzed. The percentage of rebar and CFRP are expressed in terms of cross- section of beam and percentage of offset of CFRP is expressed in terms of span of beam. All specimens were subjected to a four-point bending test under monotonic loading where load, defection, mid-span strain and failure mode were recorded up to failure. Analysis of beam is done with the help of non-linear FEM software Marc2003.

From analytical study it was found that the load carrying capacity of the strengthened beam increases from 30% to 50% at cracking, 25% to 95% at yielding and 80% to 200% at ultimate, the increment of load carrying capacity of the beam depends on the geometry of the beam, percentage of rebar and percentage of CFRP. The failure mode of the beam depends on the amount of rebar and CFRP. From analysis it was found that the optimum percentage of CFRP for fully utilization is 0.5% corresponding to the 0.33% rebar and 0.17% corresponding to 0.17% rebar. The load carrying capacity of the beam, corresponding to the final deflection allowed in the design (IS 456-2000), can be increased from 12% to 80%. From analysis, it was seen that keeping offset of CFRP from the support more than 25% is not good. On the other hand, by keeping offset of CFRP less than 25%, it increases the cost only but not strength. With the increase in percentage of CFRP, the mid-span deflection of the beam is reduced. With the increase in offset of CFRP from the support more than 25%, the mid-span deflection of beam is increased.

Thesis Title: **FINITE ELEMENT ANALYSIS AND FATIGUE DAMAGE CALCULATION OF WELDED BRIDGE K- JOINT**

Submitted by: **Rajendra Sapkota**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT

One of the most important deterioration mechanisms of steel bridges structures, which occur in service condition, is fatigue. In Nepal, numerous number of fatigue cracks has been recently reported to initiate in steel bridges in superstructures and even in sub structures. Such fatigue cracks may lead a significant influence to the traffic and even collapse of the bridges if the cracks are left to propagate. Repair and retrofitting works including investigation of fatigue mechanism for such fatigue damage are very urgent issues now. This is the research work about the finite element modeling and fatigue damage calculation of steel welded truss bridges. The Rapti Bridge of Nepal is taken as a typical case that was failed by buckling and retrofitted by welding technique.3D finite element model of Rapti bridges was created using the available SAP2000 software package. The result obtained from the linear analysis was used to find the most critical joint for fatigue damage. The analysis shows that the middle joint is the most critical joint for IRC class -A load.

For the modeling of k- joint and calculation of fatigue damage the software package ANSYS Ver.10 was used. The micro model of the k joint was model using the elements available in software package. In the FE model, 3D 20 node tetrahedral solid elements, solid 95, was used for gusset plate and diagonal members. The weld nugget was model using a two node beam element BEAM 188. Contact and target elements, Targe 170 and Contal75 were also created on the inner surfaces of the plates around the weld. The transient step loading analysis was done considering the effect of material non linearity. In the present study, numerical analysis was carried out to look into the performance of welded k- joint in axial loading with different weld radius. Strength of joint is increased with the increase of weld radius. The displacement along the longitudinal direction is decreased and the stress distribution is more uniform with the increases of weld radius. The stress life approach (S-N) curve was used to evaluate the cumulative fatigue damage. Based on the predicted stress and strain states fatigues life analysis were performed. The result of this study shows that the fatigue life of welded joint increases with the weld diameter. In this study, the weld radius 5mm has a lesser fatigue damage than the weld radius 3mm and 2mm,

Thesis Title: **NONLINEAR DYNAMIC RESPONSE OF REINFORCED CONCRETE COVERED CANAL UNDER STRONG GROUND MOTIONS**

Submitted by: **Minesh Ratna Tamrakar**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT

Underground structures have been considered to be relatively safer during the event of earthquakes. This belief has continued to make its roots in the engineers' mind until the 1995 Hanshin-Awaji earthquake (Kobe earthquake). The Kobe earthquake witnessed severe damage and complete collapse of several subway stations belonging to Kobe metropolitan subway line. Similarly, recent 1999 Chi-Chi earthquake and 1999 Kocaeli earthquake also witnessed severe damages. These events have raised the serious concerns regarding the safety of the underground structures during earthquake. In Nepal, some of the underground structures have been constructed and some are underway to construction. In light of the damages that occurred in underground structures in recent times around the various parts of the world, detailed investigation of the seismic performance of the structures that is currently underway construction and the structures that are to be constructed in future

have to be made. It is intended to study the performance of the to be constructed three-chambered reinforced concrete Covered Canal under severe ground motion due to earthquakes, which is a component of SIKTA Irrigation project. For accessing the performance of the covered canal, six different conditions of water levels have been considered. The soil investigation has not been carried out in the region where this structure is going to be constructed. So, for the purpose of the research, soil database of the head works have been utilized. The analysis showed that the covered canal is safer in the event of earthquakes. But, as the soil data used in the analysis is not the one found at the covered canal vicinity, it could not be generalized that the structure is safe in the event of earthquakes. So, it is deemed to be necessary to access the performance of the covered canal in various kinds of multi layered soil profiles. For this purpose, eleven models have been developed. These eleven models are grouped into three sets. First set consists of the three models having only one layer of soil each. Second set consists of six models with thickness and number of soil layers identical to original base case and varying the profiles by combination of soil properties. Third set consists of two models apart from base case with soil properties and number of soil layers identical to the base case and varying the thickness of the soil layers. These studies have revealed that the different types of soil profiles have got profound effect on the performance of the underground structures.

Thesis Title: EARTHQUAKE GROUND MOTION PARAMETERS FOR STRUCTURAL DESIGN IN NEPAL

Submitted by: Shailendra Kumar Sah

Supervisor: Prof. Dr. P.N. Maskey

ABSTRACT

The study on “Earthquake Ground Motion Parameter for Structural Design in Nepal” is carried out in two parts: in the first part, the probabilistic seismic hazard analysis is carried out for the Kathmandu Valley considering 10-active faults as earthquake sources; the recurrence law proposed by Gutenberg-Richter is used. The intensity of earthquake at the center of Kathmandu valley in terms of PGA and SA is obtained by adopting the attenuation law proposed by Youngs et al (1997) and poison's process for occurrence of earthquakes. Using conditional probability of magnitude of earthquake and source to site distance, the probabilistic seismic hazard curves are obtain at the bed rock, free field as well as separately assuming soil amplification factor of 2. In the second part of the study, a single envelope of the spectral ordinates are obtained using Young's et al empirical relationship due to all sources for bed rock and free field separately, which are used to simulate Time-Histories at the bed rock as well at free field . The study shows that the

contribution of Source Gosai Kunda (MCT-3.30) in Seismic Hazard curves is larger compare to the other sources and it is considered to be the vulnerable source for Kathmandu City. The program developed in Visual Fortran which generates time history from response spectra and gives good result within 20 iterations. Results are verified using Standard Software (SeismoSignal).

Thesis Title: **SEISMIC PERFORMANCE OF UNREINFORCED MASONRY BUILDING WITH FLEXIBLE FLOOR DIAPHRAGM**

Submitted by: **Shyam Sunder Khadka**

Supervisor: **Dr. Prem Nath Maskey**

ABSTRACT

Un-reinforced brick masonry has been the popular mode of the construction from centuries in Nepal. Past earthquake in Nepal had shown evidence of large damages in URM building. In the mid of the 19th century, during the Rana regime, the big palaces were constructed by un-reinforced brick masonry with timber floor. These building were constructed without seismic consideration and for the residence use only. Today, most of these buildings are used by the different Governmental and non-governmental offices in their daily use. Since, many of these buildings are over 100 years and possess the heritage value. Preservation of these buildings from future earthquake is very essential for their future use and also preserve to coming generation.

Before analyzing the actual buildings, a fictitious building having a simple plane of 6 m by 3 m is studied in detail, in order to reflect the characteristic of the unreinforced masonry (URM)

structure. The finite element method is adopted for a number of parametric analyses to determine the response of the fictitious building in terms of displacement, like:(a) the effect of the wall thickness, (b) the effect of the floor rigidity (c) the effect of opening (d) the effect of number of stories and, (e) the effect of the lateral load distribution on different floor condition.

The preliminary conclusions are used for the analysis of the real building, Shital Niwas, as a case study. Due to the complexity of modeling and analysis of the whole building, only the North wing of the building is taken for the study. The performance of the building is investigated in terms of the displacement response. It is found that the outer wall of the building is collapsed due to the excessive out-of-plane deformation. The loosely connected timber floor with masonry wall, long and unsupported URM wall, which extends throughout the height and length of the building, large sizes of the room which makes the cross wall further apart are main drawback of the existing form of the building. The conclusion obtained by the ***analysis*** of the North wing of the building can be generalized with the whole building configuration.

Graduation Year 2010

Thesis Title: **BEHAVIOR OF CFRP (CARBON FIBER REINFORCED POLYMER) STRENGTHENED RC PIER UNDER LATERAL LOAD**

Submitted by: **Anup Kumar Subedi**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT

Since FRP has gained popularity in retrofitting the RC structures, this paper presents the behavior of RC Pier before and after retrofitting subjected to monotonic lateral load. This paper is based on the results obtained from experiment performed on column-footing assembly in laboratory.

Each specimen was subjected to monotonic lateral load and load, displacements as well as the patterns of cracks and damage behavior were monitored carefully. On the basis of degree of damage observed the retrofitting of damaged specimen with carbon fiber reinforced polymer (CFRP) was varied. The retrofitted specimens were also tested under monotonic lateral load and its crack patterns, damage behavior, load and displacements were monitored carefully.

An experimental result of this study indicates that CFRP used in this work enhanced the strength and stiffness of damage column-footing specimens.

As compared to the initial capacity of the specimens the capacity of retrofitted specimens was reduced by less than 20% only.

Thesis Title: **THE EFFECT OF AMBIENT AIR TEMPERATURE ON STRIPPING TIME OF FORMWORK OF HORIZONTAL MEMBER OF HIGH STRENGTH CONCRETE IN CONTEXT OF KATHMANDU VALLEY**

Submitted by: **Piyush Pradhan**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT

Demand of High Strength Concrete in construction of high rise building is increased, due to the stability and earthquake resistance. Especially in Kathmandu Valley the number of high rise building construction is rapidly increased. The major component of the concrete construction is also the estimation of strength of concrete and the stripping time of the formworks. Maturity method is the appropriate technique for predicting concrete strength based on which formwork removal time is identified. In this thesis present some guide line of stripping time of formwork of concrete, which are identified by the experiment on the lab and the maturity method concept.

The experiment was carried with the Ordinary Portland Cement of 53 grade. Fine Aggregate and Coarse Aggregate collected

from Belkhu and Mahadev Besi. powerflow 2239 Plastisizer and micro silica were used for prepared concrete mix grade M40 and M60. The maximum size of the coarse aggregates was 12.5 mm. The concrete mix design was adopted as trial and error method. The concrete mixed proportion for M40 concrete was 0.4: 1: 1.65: 2.92 (W: C: FA: CA) and Admixture (MC-powerflow 2239) 1.2% by weight of cement and micro silica 4% by weight of cement. The concrete mixed proportion for M60 concrete was 0.29: 1: 1.35: 2.19 (W: C: FA: CA) and Admixture (MC-powerflow 2239) 2% by weight of cement and micro silica 4% by weight of cement. The compression test carried out at different age (days) of concrete from 1, 2, 3, 4, 7, 14, 21, and 28 days curing at temperature range of 5°C -10 °C, 10°C -15 °C, 15 °C - 20 °C, 20 °C -25 °C, 25 °C -30 °C, and 30 °C - 35 °C. All the experiment was conducted in IOE lab.

Stripping time of the concrete grade M40 and M60 was identified on the basis of various literatures and the experiment.

Thesis Title: **EFFECT OF HOOK ANGLE AND SPACING OF TRANSVERSE TIES OF RC COLUMN IN AXIAL**

Submitted by: **Shekhar Chandra KC**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT

Effect of different hook angle ties and the spacing of ties is investigated on axial load carrying capacity of RC columns. Axial capacities of sixteen small column and four medium columns are experimentally obtained. The progressions of damage and failure modes are found to depend upon the hook angle of ties and the spacing of transverse reinforcement. The columns with 135° ties bear the more axial load than the columns with 90° ties. Column with 90° ties opened and the longitudinal bars started buckled even in small spacing of ties. Column with 135° ties are found to be more grip to longitudinal reinforcement and they are not opened. Small ties spacing column show the high axial load carrying capacity than the column with large spacing of transverse ties.

Thesis Title: **EVALUATION OF DAMAGED PRESTRESSED CONCRETE BRIDGE GIRDER AND IT'S RETROFIT**

Submitted by: **Anil Kumar Shrestha**

Supervisor: **Dr. Roshan Tuladhar, Mr. Jagat Kumar Shrestha**

ABSTRACT

The Highway is most important mode of transportation infrastructure facility used in our country. Nepal, being mountainous terrain to plain terrain with plenty of rivers and streams, construction of cheapest means of transportation like highway becomes difficult. So, number of bridges required to cross the rivers and streams for highway. Prestressed concrete is a method for overcoming the concrete's natural weakness in tension. As a result of both accidental and intentional events in connection with important structures all over the world, explosive loads have received considerable attention in recent years. In my thesis I had selected Surai-Naka prestressed concrete bridge as a case study, which has been blast by terrorist few year back and some part of it has been damaged. This Surai Naka prestressed concrete bridge is very important, as it is only one bridge for East West highway of Nepal. So using computer application, we can evaluate the strength or say capacity of this

bridge so that developing country like Nepal can save this important bridge depending on its capacity.

During this research work , Field survey was carried out for the damage condition of bridge. I observed that anchorage block of left main girder was damaged and two number of tendon was seen totally damaged and will not be workable.

Thesis Title: HYDRODYNAMIC EFFECT OF LIQUID CONTAINING CIRCULAR TANK

Submitted by: Kiran Maharjan

Supervisor: Prof. Dr. Prem Nath Maskey

ABSTRACT

The main objective of this thesis is to evaluate the hydrodynamic effect on elevated cylindrical tank. Two type of tanks are selected for analysis. Tank-1 is tank taken from IITK/GGDMA guidelines to verify the model. Tank-2 has capacity of 1 million liter with staging height of 16m. The tank is analyzed in ansys using fluid80 element. Due to large number of degree of freedom, large numbers of sloshing modes are obtained. The time period and shell stress of the model match with calculated values. In equivalent mechanical modeling using springs, different models were tested. Among them SMiRT full discretized model is taken for analysis.

Linear analysis method was selected for the analysis. Free vibration analysis is carried out for time period of structure. In response spectrum analysis curve from IS 1893 was taken with seismic zone V. Various time history function from 0.59 Hz to 3.36 Hz were selected for dynamic loading. Dynamic nature of the tank for different earthquakes was broadly studied. The

equivalent mechanical model with spring and masses were studied. The formula used in equivalent mechanical analytical method is based on linear sloshing principle. Time period from free vibration analysis of liquid containing structure almost match with codal provision. The sloshing characteristic is totally a geometrical properties rather than material properties. Sloshing of liquid is independent of height of staging. Among different mechanical model SMiRT model showed good agreement with analytical method. The mechanical model is able to simulate the fluid structure coupled effect. The participation of sloshing in total response of structure is around 10%. Mexico and El-Centro earthquake has damping as well amplifying effect on the structure tank-1. Earthquake with frequency content larger than 2.25 Hz has only damping effect on structure tank-1. The maximum amplification of 33% produced by Mexico earthquake and 68% damping was seen in San- Fernando earthquake. The frequency of structure shifts to lower side with liquid tank filled with liquid i.e structure become more flexible. The dynamic analysis of tank-2 for Lalitpur time history, for the height of staging of 12m has only damping characteristic for various water depth ratio.

Thesis Title: **IDENTIFICATAION AND MODELING OF STRUCTURE SYSTEM OF RATO MATSYENDRANATH RATH**

Submitted by: **Biken Bajracharya**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT

The study on "Identification of Structural System of Rato Matsyendranath Rath and its Response" is carried out in three parts: in the first part, the observation of the construction of Rath during the reconstruction of Rath in Ashar 2066 at Mangal Bazar. During observation, preparation of material, making and installation of parts of Rath, measurement of every parts of Rath were recorded and interaction with people related to construction of Rath was done.

In the second part of the study, lab experiments of material used (timber), kind of joint used in construction of Rath was tested and result of theses experiment were used as input for software analysis.

In the third part of the study, software analysis of the structure was done using time history function and rotational stiffness of joint as stage; response of the Rath to assigned load was analyzed. Amount of force required to retain the deflection of

Rath was determined. Critical angle for toppling was determined calculating shifting of C.G.

Thesis Title: **PERFORMANCE OF HAUNCHES IN T-GIRDER CONCRETE BRIDGE**

Submitted by: **Rajendra Prasad Das**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT

Use of Reinforced Cement Concrete superstructures has been very common in Nepalese context. It is considered to be relatively easy to construct using local skilled manpower and higher quality of work can be achieved relatively. The super structures consist of deck slab supported by a number of concrete girders. Deck slab and concrete girder are casted monolithically so as to act as T-Girder; deck slab being flange and girder being web. Web and flange are connected to each other by providing triangular haunches/fillets with reinforcements. It is intended to study the performance of these haunches in terms of stress distribution/comparison at the haunches, maximum deflection. For the purpose two pair of 3-D solid models was created using SAP 2000, Non-linear Version 10. Each pair of models consists of super structure with and without haunches. Linear analysis of 3-d solid models is done. The variations between stress distributions were found and little variation in deflection

was found at the haunch position. So, the result from linear analysis made a demand for analyze for higher loads i.e. to go for

non-linear analysis. For assessing the performance of the haunches in terms of ultimate load carrying capacity and mode of failure, one pair of 2-D model consisting of a T-girder with flange with and without haunches were created using a Japanese Software WCOMD. The finite element models were run for analysis till failure. The ultimate load and mode of failure were found to be same in both the cases. Rather, stress level varies having lower stress level in T-girder with haunches and deflection being almost same. So, considering non-linear analysis the haunches provided between the junction of deck slab and girder has not much significant effect upon the performance of T-girder concrete bridges regarding deflection, ultimate load carrying capacity and mode of failure whereas, stresses are affected.

Thesis Title: **STRENGTH AND PERFORMANCE EVALUATION OF NEPALESE RC BRIDGE PIER USING NONLINEAR DYNAMIC RESPONSE ANALYSIS**

Submitted by: **Sikindar Kumar Chaudhary**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT

Nepal lies in one of the world's most seismically active region. During the 1995 Hyogo-Ken Nanbu (Kobe) earthquake (M 7.8), highway structures were damaged or severely affected, particularly the single - column -type RC piers. During the 1989 Loma Pita earthquake (M 7.1) in California, widespread damage was reported to the region's highways and bridges. Five different conditions of Bridge Pier have been considered with investigation of all the database of design available at the DOR. Available bore-hole soil database of the Bridge Pier have been utilized. The analysis showed that the RC Bridge Pier is safer in the event of earthquakes for simulating the ground conditions encircling the pier. The performance of the RC Bridge Pier was accessed in strong ground motion records. In this study it was intended to access the seismic performance of RC bridge piers under Gazali strong motion. It was observed in the field observation that most of the bridges in Kathmandu Valley were

having lowered bed due to scouring. The effect of strong vertical ground motion was investigated for possible reduction in flexural and shear strength of the pier. For this purpose, fifteen models have been developed. These fifteen models are grouped into three sets. First set consists of the five models having only horizontal direction of earthquake is applied. Second set consists of five models with horizontal & Vertical direction of earthquake is applied and third Set consist of the five models with Scouring is considered. These studies have revealed that have got profound effect on the performance of the RC structures.

Thesis Title: **ESTIMATION OF SITE SPECIFIC DESIGN PARAMETERS**

Submitted by: **Purushottam Karki**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT

A realistic ground motion representation such as PGA, Response spectrum etc for a specific site may be considerably different from the stipulated in the codes. For evaluating performance of a structure in the event of an earthquake, we need to estimate seismic hazard and to established ground motion at the site where the structure located. The study deals with a probabilistic method for estimation of seismic design parameters for a specific site 'Lalitapur Pati' a historically important structure. Probabilistic seismic hazard analysis is carried out considering 18 active faults as earthquake source. A suitable attenuation law, Young's et. al. (1997), developed for similar tectonic region based on worldwide earthquake data is selected. Assuming the occurrence of earthquake as Poisson's process, horizontal ground acceleration and uniform hazard response spectrum (UHRS) at various natural periods are obtained for 10% probability of exceedance in 50 years corresponding to return period of 475 years at bed rock level. The result shows that the PGA is .29g at the bed rock level. Due to lack of representative strong motion

data recorded in Nepal, synthetic ground motion is simulated in frequency domain analysis by using target spectrum matching analysis. A separate program is developed in Visual Basic language to simulate response spectrum compatible time histories. Some the results are also verified using Nonlin and SeismSignal software.

Finally, the simulated time histories are applied to soil profile of site and one-dimensional linear as well as equivalent linear analysis site response analysis is carried out to obtain PGA, time history and response spectrum at the surface of the site. The results indicate that the maximum amplification is 1.6 times to PGA at bed rock for linear response and about 1.28 for equivalent linear analysis. The nature of soil affects the amplitude of spectral accelerations and at the same time influence the frequency content of the spectrum. The smooth response spectra of surface time histories obtained from Newmark- Hall's method are close to that of NBC. Seismic design parameters like time histories, response spectra found at surface are major findings of the study which can be useful to design for new structures or retrofitting of the existing structures.

Thesis Title: **CONTRIBUTION OF SLAB WITH OPENING IN RC FRAME UNDER SEISMIC CONSIDERATION**

Submitted by: **Rakesh Sapkota**

Supervisor: **Dr. Prajwal Lal Pradhan**

ABSTRACT

Most of the prevailing codes are only able to comprise limited design criteria and specifications regarding the building plan configuration irregularities, amongst which opening in diaphragm is one of those irregularities. The existence of the opening in diaphragm is to fulfill various architectural requirements such as skylights and staircases, elevators, duct shafts, atria etc, so its presence is quite assured in any structure nowadays. Since the diaphragm distributes the lateral forces to vertical resisting components such as columns, frames and shear walls, analogy to the beam, the load carrying and moment resisting region should not be interrupted in terms of structural continuity. This thesis deals about the seismic responses of the structure with diaphragm openings taking into consideration number of parameters such as location of the opening on grid plan with relative distance in terms of natural coordinates, thickness of slab and size of column. The considered models are symmetric with definite shape and size and the materials used are

isotropic and with definite characteristics strength. Linear dynamic analysis of torsionally coupled structures subjected to response spectrum was performed using SAP 2000 assuming a rigid floor diaphragm. Later on, the seismic responses of models such as roof displacement, base shear and base moment were achieved. From the study, it was found that the model having opening in same strip did not behave similarly in terms of global responses. A couple of parameters involved viz. thickness of slab and size of column did not matter a lot in the pattern of overall building responses compared to those the affect developed by varying the location of slab opening. The roof displacement has the greater value in the no opening case since the opening make the building diaphragm flexible. Furthermore, the global torsion of the structure and local torsion of the critical elements were found almost nil in the model where the slab position were placed in symmetry which was quite expected. Also, the maximum value of base shear is in no opening case with maximum time period since the presence of slab increases the mass of the structure. Moreover, there exists a lower value of time period in model where the opening is proposed in four corner grids. These models also reflect the maximum value of base shear which is quite obvious to have in stiffer models.

Thesis Title: **LIVE ROAD RESPONSE OF THE EXISTING TRAFFIC ON THE HIGHWAY BRIDGES OF NEPAL**

Submitted by: **Bhanu Joshi**

Supervisor: **Dr. Roshan Tuladhar**

ABSTRACT

Highway bridges are long life structures, so there is always the question when developing traffic loading model as to what allowance to build into it to allow for unforeseen changes in the traffic . while there is usually some form of control over the weight and dimensions of individual vehicles.

The percentage of heavy goods vehicles crossing a particular structure could exceed the value assumed in the development of loading model and so reduced the margin of safety.

This is perhaps needed to regularly monitor existing traffic so that it can be identify any deleterious change in traffic patterns. Which might affect the extremes of the loading being carried by particular structure.

if the extreme loading were such that they were felt to be jeopardizing the safety of the structure then some form of control and remedial action must be taken.

This is a research work towards the assessment of live load response of three axle truck on highway bridges (RCC simply supported) of Nepal. The axle load survey was carried out at few places of east west highway and gross vehicle weight was taken from weighing machine station at Hetaunda and Bhairawa. .At 95% confidence level axle load is derived using theory of probability. It has been observed that most of the three axle truck surveyed were over loaded. The front axle load is found 67.5 KN rear I and rear II142KN and 136.5 KN respectively.

With this model truck live load response is calculated for span 10m to 30m considering normal and jam situation and compared with various loading standard presently being used in our country.

The research shows that immediate action should be taken to control axle load limit and further for more than three axle truck present axle load limit need to revised.

Thesis Title: SEISMIC PERFORMANCE ASSESSMENT OF TYPICAL RESIDENTIAL RC FRAMES OF KATHMANDU WITH BEAM TO BEAM CONNECTIONS

Submitted by: Maheshwor Pokharel

Supervisor: Dr. Prajwal Lal Pradhan, Dr. Roshan Tuladhar

ABSTRACT

Nepal is located in one of the world's most seismically active zone and predicted that big earthquake occurred within certain repetition of time. It is predicted that if the earthquake of 6 Richter scale happened in Kathmandu, minimum death will be 69,000 which is due to declining construction practices, uncontrolled urban planning and violating building codes. Thousands of the concrete houses have been constructing every years with/ without proper engineering design. Among them beam to beam connection without column is one of them. This type of connection occurred when the column under crossing of the beam got removed. Some of them are occurred during the design due to the architectural requirement of rooms, land shapes and closeness of two columns where as some of them occurred by removing close column during construction. In order to know the influence of beam to beam connections, 150 building

drawings of KMC-16 which were sanctioned from KMC in fiscal year B.S. 2063/2064 (2005/2006 AD) were collected and analyzed. It is found that 67 percentages of those buildings have beam to beam connection and most of them have connection at the center. Then, the plan of beam to beam connection at the center is taken and from that other four different models are made by adding and removing beams and columns. All these buildings are firstly modeled in SAP for pushover analysis and then to COM3 for nonlinear dynamic analysis by using Kobe Earthquake. From the analysis from COM3 it is found that beam to beam connection at the center have large top displacement, low base shear, maximum internal stresses (BM, and SF) and damage occurred in minimum strain in comparison to other model which shows that beam to beam connection without column deteriorate the strength of building and should be avoided as far as possible.

Thesis Title: **BEHAVIOR ASSESSMENT OF LOCALLY MANUFACTURED COUPLES**

Submitted by: **Suraj Rajak**

Supervisor: **Dr. Prajwal Lal Pradhan**

ABSTRACT

Manufacturing, fabrication, and transportation limitations make it impossible to provide full length continuous bars in some reinforced concrete structures. In general, reinforcing bars are stocked by lengths of 12-18m. For that reason, and because it is often more convenient to work with shorter bar lengths, it is frequently necessary to splice bars in the field.

Proper splicing of reinforcing bars is crucial to the integrity of reinforced concrete. ACI Code states: "splices of reinforcement shall be made only as required or permitted on the design drawings, in the specifications, or as authorized by the engineer." Great responsibility for design, specification, and performance of splices rests with the engineer who is familiar with the structural analysis and design stresses, probable construction conditions and final conditions of service can properly evaluate the variables to select the most efficient and economical splice method.

Lap splicing, which requires the overlapping of two parallel bars, has long been accepted as an effective, economical splicing method. In projects with smaller bar sizes such as 020mm or smaller, lap splices have performed well over the long run. Continuing research, more demanding designs in concrete, new materials and the development of hybrid concrete/steel design have forced designers to consider alternatives to lap splices such as welded splices or mechanical connectors. However the welded splices are found to be more expensive, time consuming and need more workmanship. So in this study, mechanical connector is explored as an alternative to the traditional splicing methods.

Thesis Title: **SEISMIC BEHAVIOR OF PILED RAFT FOUNDATION WITH ENCASED INTERMITTENT STEEL GRILLAGE**

Submitted by: **Soyuz Gautam**

Supervisor: **Prof. Dr. Hikmat Raj Joshi**

ABSTRACT

Demand of high-rise building in urban area of Nepal, especially in Kathmandu metropolitan city, is soaring day by day. In this present scenario, the use of raft foundation is inevitable because of the weak soil condition of the Kathmandu city. Again, the use of pile becomes more important when the height of the building is to be increased in the limited plinth of the core urban area. The design requires either large depth of raft for shear safety or heavily congested shear reinforcements with reduced concrete depth required for flexure only. One of the economical and practical solutions for such case can be intermittent grillage foundation with structural steel placed for shear nearby the column locations only and with reduced depth of concrete in the foundation. However, no code specifies explicitly on the amount of intermittent grillage as such. Therefore, in this study, behavior of the intermittently placed encased steel grillage under high column load was investigated both using 2D linear elastic modeling as well as 2D nonlinear dynamic modeling both with

and without consideration of effect of additional piles below the raft. Finite element modeling of the soil were done both as one dimensional spring element in linear model of SAP2000 and two dimensional interface plane elements in nonlinear model in WCOMD. Nonlinear dynamic analysis was also performed under strong ground motion of Kobe earthquake in horizontal direction considering 2D soil structure interaction as well as dynamic effect from structural frame to the raft in order to predict the behavior of such foundation system in the real soil condition of Nepal.

The results indicate that the design provision of the intermittent grillage for shear safety requirements and provision of top and bottom reinforcement bars for flexural action of raft is safe enough by at least of a factor of safety of 2, considering all possible stress/strain states in grillage and other components. The shear contribution from the top and bottom reinforcements for the raft slab can also be considered at least with a factor of 1.5 and the amount of intermittent grillage can be reduced by at least a factor of 2. The additional pile improves the foundation system in terms of settlements and loads, and dynamic analysis shows the failure section is shifted to the periphery of the raft under the column where there are high loads.

Thesis Title: **DYNAMIC ANALYSIS OF TRADITIONAL BRICK MASONRY BUILDING**

Submitted by: **Sujan Tripathi**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT

The traditional historical buildings have great value in the human society. Especially in Nepal, these building are very important because it has a great cultural value in Nepalese society. The traditional historical buildings are generally constructed with low- strength brick masonry with timber floor. In these days, these buildings are mostly used for different cultural purpose. Thus, all of the community members and government bodies are always worried about the preservation of these buildings. Now a days, many of the historical buildings are in a critical stage. There are many reasons for that such as the buildings are stand from more than 3oo years without any major maintenance work and the other is that buildings are not design for earthquake before construction so these are more vulnerable during seismic action. Therefore the preservation of these historical traditional buildings are more challenging work in this days, but which is very important to continue our culture.

The existing traditional historical brick masonry building, having the length 16.445m, width 5.56m and the total height of 6.405m, which was constructed with local materials before 300 years ago, is taken as a research building for this research work. The non-destructive test (Acoustic Emission Test) of the research building "LALITAPURA PATI" has been carried out at the initial stage of this research work, which is essential to determine the actual condition during this age of Lalitapura Pati. This test is also important to find some properties of this building. Mainly this test is focused for finding the effect of cavities, formed due to deteoriation of mortar joint and the bricks being its longer age.

The 3-D Finite Element Model of this research building has been built by considering all of major element of the building to make it as real as possible by using a strong FEM based software "ANSYS V.10". There are four types of model of this building are built in ANSYS with the different building configuration such as: (i) building without floor joists and roof truss, (ii) building only with roof truss, (iii) building with floor joists and roof truss and, (iv) building with rigid floor diaphragm and roof truss, for the purpose of comparative study.

Graduation Year 2011

Thesis Title: **REGULATION OF CODES IN SEISMIC DEIGN OF BUILDING**

Submitted by: **Deepak Kumar Gupta**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT

The present thesis work deals with comparison of the code provisions in seismic design of building stipulated in three seismic codes namely; National Building Code of Nepal NBC 105:1994, Criteria for Earthquake Resistance Design of Structure IS1893:2002 and Uniform Building Code UBC1997.

The regulation of design and construction worked out for a region may not be suitable for other regions. Codal provisions of codes of developed countries may reflect the recent technological development, which may be incorporated in the other countries for betterment of the construction quality. The base shear and pattern of its distribution and fundamental time period determined as per codal provisions of the three codes has been compared. The work presented also emphasizes upon studying the development of the Nepalese Standard codal provisions regarding buildings. Amendments to be done to these provisions

in the subsequent revisions of the Nepalese Standard have been spotted out.

A typical six storey building has been analyzed for case study using Seismic Coefficient Method and Nonlinear pushover analysis. The base shear and pattern of its distribution, fundamental time period and storey displacement has been numerically found out as per codal provisions of the three codes has been compared. The behavior of building has been compared using nonlinear pushover analysis.

It is concluded that the basic philosophy of the codes of these countries are same, although
regulations might be different. The results of the study indicated that the base shear and period of vibration value by UBC1997 are higher among other codes. The ductility behavior
of building analyzed by UBC1997 is better than other two codes. It is observed that the results obtained by the load combination including dead load and earthquake load are more than other load combinations.

Thesis Title: **STUDY ON REINFORCES CONCRETE FRAME WITH SOLID INFILL BRICK MASONRY USING ARTIFICIAL NEURAL NETWORK**

Submitted by: **Ajay Kumar Gupta**

Supervisor: **Dr. Prajwal Lal Pradhan**

ABSTRACT

Despite being the most common construction practice throughout the ages, infills have not found the space it deserves, in the structural design. There is lack of proper and easy method to consider the effect of the in-filled. So, this research is a small effort in the search of the alternative approach for analyzing the infill frames. The ,FEM Models are normally incapable of considering all the effecting factors such as non-linear behavior of the infill materials, lack of fit, non-homogeneity of the materials, etc. This research gives some idea to the structural engineer how to guess initially the parameters of interest during the design of infills. Structural design process is an iterative process and an approximate initial guess can reduce the time and cost involved in the analysis. The tentative design parameters can be predicted using the Artificial Intelligence and this computing power of the modern day computers has been used to fulfill the intended purpose. The data sets, which are generated by

computer from the simulation of the infill-frame structure done in sophisticated software (ANSYS vl0.0) capable of non-linear analysis, are used for the training of Neural Network. Few other unique data sets are taken for the validation of the Network trained. The comparison of the results from the ANN and that of software were in reasonable agreement with each other except in few rare cases.

Thesis Title: **ANALYSIS OF BRICK MASONRY INFILL FRAME WITH OPENING USING ANN**

Submitted by: **Dinesh Kumar Gupta**

Supervisor: **Dr. Prajwal Lal Pradhan**

ABSTRACT

The study has been targeted to the infill which has been the most common construction practice throughout the ages and yet has not found a profound space in the structural design. This research is a small effort in the search of the alternative approach for analyzing the infill frames. In the present practice the infill walls are considered to be the non-structural and ignored in the analysis, because there is no proper and easy method available for considering the effect of the infill. The FEM Models normally consume lots of human effort and time to consider all the effecting factors such as non-linear behavior of the infill materials, lack of fit, non-homogeneity of the materials, etc. This research givejs the way-out for the initial guess of the parameters that are of interest to the structural engineers in designing the infill. The tentative design parameters can be predicted using the Artificial Intelligence and this computing power of the modern day computers has been used fulfill the intended purpose.

The computer is trained with the data sets generated from the simulation of the infill-frame structure done in sophisticated software capable of non-linear analysis (ANSYS v 10.0). Afterwards the trained Artificial Neural Network is used for the validation of the data. The comparison of the results from the ANN and that of software were in reasonable agreement with each other except in few rare cases.

Thesis Title: **MICROZONATION OF SEISMIC INPUT**

Submitted by: **Dibyashree Lohani (Poudyal)**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

There is an urgent need for a seismic microzonation for the Kathmandu valley because it is an area of high seismic activity. The Kathmandu valley is underlain by thick lacustrine quaternary deposits which are susceptible to ground motion amplification. The realistic modeling of seismic ground response analysis is very important in the seismic microzonation. This however greatly depends on the availability of detailed subsurface geological and geotechnical information as well as strong ground motion records. As there is only limited borehole data on depth to bedrock, geophysical surveys and geotechnical properties of the soil type of Kathmandu valley, a one dimensional seismic response modeling software could only be done based on the number of assumptions for geotechnical parameters and soil depth.

The earlier simulated time history by sha, Shailendra (Earthquake ground motion parameters for structural design in Nepal) was used. Altogether 14 boreholes profile from different sites of the Kathmandu valley was used for the seismic response analysis. The results *indicate* that the maximum amplification is

1.6 times to PGA at bed rock for linear response. The application of GIS technique provides an efficient tool in seismic microzonation particularly for the generation of contour. However a more extensive study on seismic microzonation is required including geophysical surveys, SPT soundings and the establishment *of* a series of strong motion accelerographs in order to produce maps that can be used for planning and resource management purposes in the valley.

Thesis Title: **CODE PROVISION FOR SEISMIC ANALYSIS AND DESIGN OF BUILDINGS**

Submitted by: **Sushma Dhungana**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

Nepal, ranked 11th among the most earthquake prone countries, lies between the collisions of Indian to the Eurasian plate, which is moving continuously resulting into devastating earthquakes within the region. For the protection of public health, safety and general welfare, building design and construction should be done well abiding by the seismic provisions set in the country's building codes of practice. Different countries formulate codes that best suit their countries in accordance with their respective social and technological background as well as their experience and knowledge. Developed nations like America, Australia and Canada have a long history of development of building codes with timely revisions to incorporate modern technologies and philosophies. Nepal's first building was promulgated in 1994. The development of Nepal national building code is still at tender age. Before or even after the promulgation of national building code, Indian codes of practices are extensively used in building design and construction due to the inadequacy of Nepalese standards. Seismic provisions incorporated in NBC

105:1994 are mostly based on IS 1893:1994. It is high time now that the relevant revisions be made in Nepalese standards since substantial advances have been achieved in the knowledge related to seismic resistant design of buildings and structures during the past 15 years since 1994. Reference documents like Indian Standards, NEHRP and other codes, which were referred then had gone through series of revisions till to date.

For the identification and determination of important provisions, a comparative study among the seismic provisions in NBC 105:1994, IS 1893 (Part I):2002 and IBC 2006 is conducted. This research intends to compare and critically analyze different provisions stated in different codes along with a case study of a building located at Kathmandu. The building is analysed and designed for seismic lateral load by both the seismic coefficient and response spectrum methods using ETABS v.9.5 as per codes. Comparison of building outputs in terms of seismic lateral forces, base shear, storey shear, displacement, drift ratios, flexural and shear reinforcements is made. One of the major conclusions is that the responses when designed by IBC 2006 are found to be the most conservative.

Thesis Title: **TIME HISTORY ANALYSIS OF CABLE STAYED BRIDGE SUBJECTED TO NEAR FAULT PULSE TYPED GROUND MOTION**

Submitted by: **Kirty Tiwari**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

Recent research has shown that pulse type earthquake ground motions that result from forward directivity effects can result in significant damage to structures. This study is carried out to gain knowledge on effect of such pulse on the behavior of cable stayed bridge. The pulse type ground motion were selected and scaled with site based response spectrum. Nonlinear time history analysis is performed on selected ground motion considering geometric and material nonlinearity. The results show that the geometric non linearity has a much smaller effect on the bridge behavior than material nonlinearity. The overall safety of a long span cable stayed bridge depends primarily on the material nonlinear behavior of individual bridge components. It is found that neglecting pulse type ground motion might underestimate the damage potential of the earthquake ground shaking. Ground motion with pulse gives much value although the spectral acceleration value is less. Time history analysis shows that

response is maximum when that earthquake has more spectral acceleration near its fundamental frequency and also pulse velocity's period is near the period of structure. It is observed that under earthquake the tower start yield and plastic yield occur on some parts of truss that is connected with cable. Failure analysis of cable show that the factor of safety of most cables greatly reduced and reaches near 1 under considered poise type ground motion. Analytical models indicate that traditional analysis methods are insufficient to capture the full effects of pulse type ground motion.

Thesis Title: **TEST AND SIMULATION OF BACK MASONRY WALL OF HISTORICAL BUILDINGS**

Submitted by: **Jhapat Bahadur Thapa**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

The preservation of the historical heritage structures is the prime concern in today's world. Historical structures are the important due to several aspects such as historic and archaeological, cultural and religious, traditional and architectural, social and economical. These are the assets identity of the nation. Generally, Nepalese historical structures are made of unreinforced masonry which has low shear resistance capacity. On the other hand, earthquake is the major concern from tectonic events in the Himalayan belt. To conserve these structures from such natural calamities the strength of these structures should be assessed. Several researches have been in different countries of the world to find out the strengthening measures at specific conditions at their locality. One particular method may not be applicable to all types of structures. Therefore, appropriate method should be applied for specific purpose. The conduction of laboratory testing would be the best solution of understanding historical structure's material behavior. The mechanical

properties are the basic parameters for computer simulation work. Old bricks and mortars were collected and tested at similar condition of construction procedures. Different test procedures were conducted on the laboratory to investigate the mechanical and structural properties of its constituents and brick masonry wall. The simulation was done using ANSYS general code. Due to the in plane loading condition, 2D plane stress approaches is applied. Four noded rectangular isoparametric element (Plane42) is chosen to find out the stress strain and shear parameters of the brick masonry wall of historical building. The main aim of this study is to reduce the large experimental cost using computer approach in elemental part. Masonry is typically a non-elastic, non-homogeneous, and anisotropic material composed of two materials of quite different properties: stiffer bricks and relatively softer mortar. Under lateral loads, masonry does not behave elastically even in the range of small deformations. Masonry is very weak in tension because it is composed of two different materials distributed at regular intervals and the bond between them is weak.

Thesis Title: **SEISMIC PERFORMANCE ASSESSMENT OF HIGH RISE BUILDINGS**

Submitted by: **Dharma Ratna Maharjan**

Supervisor: **Dr. Prajwal Lal Pradhan**

ABSTRACT

Construction of high rise buildings in Nepal is increasing from last five years. As Nepal lie in high seismically active region, the performance of these buildings should be known. The building performance level should be the desired condition of the building after the design earthquake, decided upon by the owner, architect, and structural engineer, and also is the combination of structural performance level and non-structural performance level. In the design of high rise buildings with existing codes is still a challenge, as the available codes do not specify the total requirements for high rise buildings in high seismic area and are much restrictive in materials and design methods. In other to know the performance of these high rise buildings, drawings were collected from Sahari Bikash, of Kathmandu Metropolitan City, which were sanctioned for construction in the fiscal year 2065/2066. Three building models were prepared; with regular plan, irregular in plan and irregular in height. All the buildings were first modeled in SAP2000 and ETABS for pushover analysis and then in PERFORM-3D, for nonlinear dynamic

analysis, by using ELCENTRO earthquake, and nonlinear pushover analysis. Comparing the results obtained from linear and nonlinear models it is found that the plan with irregular plan has maximum roof displacement, low base shear and low ductility as compared to other buildings, and thus should be avoided if possible.

Thesis Title: **STRUCTURAL PERFORMANCE OF MECHANICAL COUPLER IN REINFORCED CONCRETE BEAMS WITH TMT BARS**

Submitted by: **Shree Krishna Shrestha**

Supervisor: **Prof. Dr. Hikmat Raj Joshi**

ABSTRACT

In almost all reinforced-concrete structures, some reinforcing bars must be spliced. The required length of a bar may be longer than the stock length of steel, or the bar may be too long to be shipped conveniently. In either case, rebar installers end up with two or more pieces of steel that must be spliced together. Proper splicing of reinforcing bars is crucial to the integrity of reinforced concrete. ACI Code states "splices of reinforcement shall be made only as required or permitted on the design drawings, in the specifications, or as authorized by the engineer." Great responsibility for design, specification, and performance of splices rests with the engineer who is familiar with the structural analysis and design stresses, probable construction conditions and final conditions of service can properly evaluate the variables to select the most efficient and economical splice method.

Lap splicing which requires the overlapping of two parallel bars has long been accepted as an effective, economical splicing method. In project with small bar sizes such as 19mm and 25mm, relatively low yield stress in steel and building heights of 15 stories or less lap splices have performed well over the long run. In recent years, however, there has been a shift. Structural concrete building frames are being pushed to 100 stories and more. Codes frequently require such long laps that steel becomes congested at splice location; sometimes the laps are truly impossible for lack of room. Location of construction joints, provision for future construction or a particular method of construction can also make lap splices impractical. In addition, ACI Code does not permit lap splices of larger than 035 mm. Continuing research, more demanding designs in concrete, new materials and the development of hybrid concrete/structural steel designs have forced designers to consider alternatives to lap splicing. Such as welded splices or mechanical connectors. However the welded splices are found to be more expensive, time consuming and need more workmanship. So, the structural performance of mechanical connection in RC flexural beam has been studied in this thesis work.

Thesis Title: **SEISMIC VULNERABILITY ANALYSIS OF HISTORIC CITY**

Submitted by: **Sujan Shrestha**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

The research is carried out on the possible vulnerability of the buildings existed in the city after major earthquake. A seismic risk assessment of buildings using two level of assessment is performed.

First level of survey is conducted from the street by rapid visual screening method. Data are collected by observation of building from sidewalk in street. The procedure has mentioned the general parameters of buildings like Number of storey, existing condition, type of material used, floor condition, type of building, dimension of shear wall, masonry wall etc. By using this procedure a database of existing buildings in GIS and ranking of building according to different parameter is obtained. From the first level of analysis, representative buildings are chosen for next level of analysis.

Second level of analysis is performed by structural analysis of buildings by macro level of finite element modeling using SAP

2000. Floors are model as semi-rigid timber floor and masonry as solid element. Free vibration analysis is performed to check the time period of the buildings and it shows that masonry buildings in the city has less than 0.25 sec of time period. Results shows that the stresses developed at the corners and openings of the buildings are higher than the permissible values. Maximum failure of the masonry blocks are due to the tensile bending stress developed. Shear stress is found to be higher in mid height of pier and spandrels. Compression is found maximum near corners of opening like door and window. So, openings increase the vulnerability of the building.

As a whole buildings are found vulnerable for future earthquake.

Thesis Title: **STRUCTURAL PERFORMANCE OF MECHANICAL COUPLER IN REINFORCED CONCRETE FLEXURAL MEMBER WITH CTD BARS**

Submitted by: **Sushil Shrestha**

Supervisor: **Prof. Dr. Hikmat Raj Joshi**

ABSTRACT

Mechanical splicing is not still familiar in Nepal among construction field. High rise buildings and other huge constructions are arising here. Providing single rebar is not possible everywhere due to length, transportation and convenience to work. Lap splicing bring problem of congestion, high cost and limitation of length and diameter of rebar. In view of economy and structural performance mechanical splicing is the better solution of conventional splicing system or lap splicing. Mechanical splicing also reduces the problem of insufficient lap length in common construction where proper supervision is not reach. Mechanical splicing perform almost same as the not spliced rebar in both monotonic and cyclic loading conditions. It is very important to produce mechanical splicing coupler in commercial way in contest of Nepal to bring in advanced technology to our construction field.

The better structural performance of mechanical splicing is tried to prove by both experimental and WCOMD analysis in this research work. Nine numbers of beams are tested in laboratory and fourteen beams are analyzed by WCOMD software. Both of the method proved that mechanical splicing has better structural performance than lap splicing.

Thesis Title: EFFECT OF SHEAR WALL ON SEISMIC PERFORMANCE OF BUILDING

Submitted by: Rockey Shrestha

Supervisor: Prof. Dr. P. N. Maskey

ABSTRACT

Nepal is a seismically vulnerable country as it lies in Subduction zone Indian-Australian and Eurasian plate. Earthquakes are one of the nature's greatest hazards to life on this planet. It poses a unique engineering design problem in most of civil engineering structures and the probability that any given structure will never be affected by a major earthquake is very low. The optimum engineering approach to this condition is to design the structure so as to avoid collapse in the severe possible earthquakes, thus ensuring safety against loss of life, but accepting the possibility of damage.

Demand of high rise buildings in the urban area of Nepal, especially in Kathmandu, is soaring day by day. In this present scenario necessity of shear wall has become important day by day. This research is primarily intended to study about effect of shear wall on the high rise buildings. The effect has been determined in terms of displacements, drift index, fundamental time periods aid base shear due to static load cases and response

spectrum cases on different storied buildings varying from ninth storied to twenty first storied with or without shear wall. A typical multi-storied building is considered for the study of effect of shear wall.

Modelling of buildings has been performed in ETABS version 9.5. Beam and columns are modelled as three dimensional frame elements having six degree of freedom in each node while slabs and shear nails has been modelled as shell elements having six degree of freedom in each node. For the analysis to be simple floor slabs are assumed to be rigid in their own plane. After modelling, static load analysis as well as response spectrum analysis has been performed. Analysis has been limited within the elastic limit After the analysis has been performed, it is found that dynamic analysis gave low values in terms of displacements, drift index and base shear as compared to static analysis. It is also found that in bare farmed structure maximum drift occurred at one- fourth of total height of building, after placing of lift maximum drift occurred at half the height of the building and after placing rectangular shear wall maximum drift occurred at three-fourth height of the buildings.

Thesis Title: **RETROFITTING STRATEGIES FOR TYPICAL NON-DUCTILE RCC FRAME RESIDENTIAL BUILDINGS**

Submitted by: **Raja Ram Thapa**

Supervisor: **Mr. Jishnu Subedi**

ABSTRACT

The effectiveness of seismic retrofitting applied to enhance seismic performance was assessed for four 3-storeyed non-ductile Reinforced Concrete (RC) Framed building structures of Kathmandu. The responses of the structures were predicted using nonlinear static analysis (Pushover Analysis). Ahmed Ghobarah (2004) criteria, which are for ductile as well as non- ductile structures, were used to evaluate the seismic performance of the selected buildings. Through simplified static nonlinear structural analysis, the seismic performance of the reinforced concrete (RC) framed building structures were evaluated and five retrofit techniques were selected and applied , to the structure. In addition, the effectiveness of the applied retrofit techniques was assessed through the development of pushover curve and response spectrum curve in ADRS format.

Based on the seismic evaluation, five retrofit techniques were applied to enhance the seismic performance of the structure;

addition of internal steel bracing, addition of external steel frame, addition of shear walls, addition of dampers and addition of base isolators. The retrofitting strategies selected were based on the judgement of minimum intervention in the existing building components. The retrofits were selected to impact the major structural response parameters: stiffness, strength and ductility. External steel frames were placed parallel to external RC frame and connected the both types of frames by steel beams. The steel frames were located in back side of the building for x and y direction where architectural view is not so important. For internal steel bracings, shear walls and dampers retrofitting strategies, they were added to two bays of each X-direction and Y-direction throughout the building height. Similarly for base isolators, lead rubber bearing was taken for study and placed just below the first storey columns at tie beam bottom level.

Nonlinear static analyses were performed to predict the seismic behaviour of the retrofitted structure. Based on the analytical results, seismic evaluations were conducted.

Thesis Title: **SEISMIC EVALUATION OF HISTORICAL TEMPLE**

Submitted by: **Ukesh Lal Bataju**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

Kathmandu valley is a splendid dwelling area with many historical and traditional monuments, with historical and archeological importance. So Preservation of these monuments against possible earthquakes is of utmost concern in view of conservation needs. The present study deals with the seismic evaluation of one of those monuments i.e." KasiBishwanath temple" built in late 1708 A.D.

The most efficient and appropriate model is adopted in the seismic evaluation with reference to the previous study carried. The seismic evaluation of the selected temple is carried out by three dimensional analysis of the structure using finite element method. For the analysis, the brick work is discretized as the eight nodded solid elements and the timber beams and the joists as frame elements with the contact element between the joint between brick and timber element. The flexible timber floor is duly considered. The Building is assessed for various load cases including gravity loads and earthquake effects in terms of

response spectra and Seismic coefficient method. The response spectra curve is taken from IS: 1893-2002. The vulnerable parts of the temple are determined during earthquake excitation.

Thesis Title: **SEISMIC PERFORMANCE ASSESSMENT OF EXISTING AND STRENGTHENING RESIDENTIAL RC FRAME BUILDINGS**

Submitted by: **Sushil Dhungana**

Supervisor: **Dr. Jishnu Subedi**

ABSRTACT

The study is carried out to assess the performance of typical Reinforced concrete (RC) frame structure buildings prevalent in Kathmandu valley and to evaluate increase in performance of the buildings by stage wise retrofitting of columns. As structural response to strong earthquake ground motion cannot be accurately predicted due to large uncertainties and the randomness of structural properties and ground motion parameters, the most useful tool for performance evaluation for practical purpose is to use pushover analysis.

This thesis discusses a brief overview of the non-linear static pushover analysis methods, Pushover analysis reflect the displacement of the structures on multi-mode system, thus the results are also compared with multimodal pushover analysis

The Pushover analysis was again carried out in retrofitted structure to find next set of columns which have reached collapse stage, the process was carried out until final performance level was reached or when there was no further increase in performance level. It has been found that the buildings retrofitted with concrete jacketing fulfill the deflection requirements compare to the existing buildings.

Additionally, some parametric study has been done, such as the P-Delta effect & comparison of default, AC1 and Fibre hinges & comparison of different types of rebar's on column jacketing. And the result showed that there is no P-Delta effect in the pushover analysis, also the Fibre hinges are more accurate for modelling, however the fibre hinges are only applicable only for flexural response, and different types of rebar's used for columns jacketing do not have effect on performance.

Thesis Title: **SEISMIC VULNERABILITY EVALUATION OF REINFORCED CONCRETE BRIDGE PIERS**

Submitted by: **Mohadatta Bhatta**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

Nepal is seismically vulnerable country because it lies in sub-duction zone of India- Australia and Eurasian plate. Transportation networks are critical lifelines and their seismic risk is of prime importance to mitigate the possible disaster. In general, concrete bridges as intrinsic components of communication networks may be critical. There has been a need to assess the seismic vulnerability of the existing highway bridges and to make them hazard resilient, if necessary.

In this research, it is primarily intended to assess seismic vulnerability of reinforced concrete bridge piers that have been constructed according to the conventional construction practice in Nepal. The seismic vulnerability of highway bridge piers is determined in terms of fragility curves which represent the probability of failure or damage due to various levels of strong ground motions. In view of scanty earthquakes records in the

region the fragility curves are developed analytically using seismic response approach.

A combination of linear and nonlinear elements is assumed for finite element modeling of different bridge components. Mandar confined and unconfined concrete model and park steel model is taken for material nonlinearity that is assumed only within plastic hinge zone of the piers. Capacity of the bridge pier is determined by pushover analysis. Nonlinear dynamic response analysis is performed using the simulated ground motion time histories. With the convolution of seismic hazards and bridge pier vulnerability, analytical fragility curves are determined. Using the fragility curves, it is concluded that for seismic hazard level 10% probability of exceedance in 50 years (Return Period 475 years) the bridge pier has probability of failure 11.73%, 1.84%, 1.19% and 0.06% corresponding to slight, moderate, extensive and complete damage respectively.
For more generalized conclusions, it is necessary to carry out such works for all types of existing bridges in Nepal.

Thesis Title: **EFFECT OF LONGITUDINAL GRIDER SPACING ON BRIDGE DECK RESPONSE**

Submitted by: **Sudip Pathak**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

Conventionally, the bridge superstructures are designed either with larger girder spacing or shorter, which may results in either saving weight and cost or may cause indirect effect in deck response. The superstructure may become either more slender or more flexible or vice versa. To overcome the best design performance criteria, it is necessary to observe the deck response by choosing appropriate girder spacing. If the spacing of girder is larger, the deck response is also influenced in same proportion of girder » spacing or vice versa.

In context of Nepal, most of the bridge design assumes the number of girders and their spacing without any prior thoughts. Also, various parameters, i.e. economy, strength and durability, have to consider while choosing the appropriate girder spacing. The necessity arises that what will be the effect of girder spacing on bridge deck response. Therefore, this investigation is carried out to determine the effect of longitudinal girder spacing on bridge deck response.

The purpose of this investigation is to evaluate the use of the commercial finite element Software SAP 2000 for the analysis of reinforced concrete bridge decks and to employ this analysis package to determine the effect of girder spacing on deck response. In this investigation, a three dimensional finite element model is developed to predict the overall structural response of the bridge. The girder moments, shears, deflection in the girder and stress in deck slab, are predicted and results of these effects are employed to find best design criteria with optimal value.

Thesis Title: **SEISMIC DEFORMATION ANALYSIS OF ROCKFILL DAM**

Submitted by: **Yuman Shakya**

Supervisor: **Dr. Rajan Suwal**

ABSTRACT

The purpose of this study is to analyze a rockfill dam focusing its core-shell interface as it is the major factor for the core settlement and similarly core settlement leading to dam failure. In the present research this non-homogenous nature is addressed in term of core-shell interface and analysis were done for the purpose of comparative visualisation of this slippage phenomenon that is likely to occur. And also a comparative analysis is performed between rockfill dam with vertical core and incline core in terms of its structural strength. Finally, the permanent settlement of the crest is calculated by dynamic analysis utilizing the chart developed based on Newmark's analysis procedures. Static analysis and free vibration analysis were performed using ANSYS and for the time history analysis SAP 2000 v14 is used. The recorded N-S and vertical acceleration components of the famous Imperical Valley earthquake of May 18, 1940 (El Centro, California, USA) are taken as the prescribed input ground motion. Linear direct integration time history analysis based on Wilson-0(6=1.42)

incremental algorithm is adopted. Rayleigh damping coefficients were calculated based on the time period obtained from free vibration analysis. The flexible foundation model is adopted for the analysis process based on the stress criterion. For calculating the hydrodynamic added mass Westerguaard's formulation of added mass is used in case of the dynamic analysis and also for the chart to predict the potential permanent settlement of the crest, the IS guideline is simply followed.

Thesis Title: **COMPARATIVE STUDY OF STRUCTURAL COST OF SEISMIC RESISTANT RC BUILDINGS**

Submitted by: **Ramesh Gnawali**

Supervisor: **Dr. Hari Ram Parajuli**

ABSTRACT

Nepal is seismically vulnerable country because it lies in subduction zone of India- Australia and Eurasian plate. Buildings are critical lifelines and their seismic risk is of prime importance to mitigate the possible disaster. There has been a need to assess proper design and to make them hazard resilient.

Buildings of various categories are selected for the analysis by looking into number of stories, floor area, structural configuration, location and construction materials. Structural analysis is done in finite element based software SAP2000 v14 and actual structural requirement found is compared with existing construction detail shown in structural drawing.

From the analysis it is found that total cost of the buildings are not significantly different but in existing construction major structural component of building, columns are seen unsafe, beams are over safe; which in not proper construction. It can be

concluded that only cost will not increase the strength of the building but the proper design is also equally important.

Thesis Title: **PERFORMANCE OF RC FRAME STRUCTURE WITH VARIOUS BEAM TO COLUMN FLEXURAL CAPACITY RATIO**

Submitted by: **Sudip Karanjit**

Supervisor: **Dr. Jishnu Subedi**

ABSTRACT

The effectiveness of various strong column weak beam (SCWB) factors to enhance seismic performance is assessed for Reinforced Concrete (RC) Framed building structures. Strong column weak beam is basically the column over-design concept in which the ratio of sum of plastic moment capacity of column to the sum of those in beam is kept greater by some factor in each joint assuming that this keeps column in elastic range even after formation of plastic hinges in the beams. As formation of plastic hinge at the column end results in storey side sway mechanism leading to the collapse of the structure above, column over-strengthening is taken as a key concept by various building codes in order to ensure the stability' of structure while undergoing large displacement.

Although shear capacity design factor can be found similar in most of the building codes ranging from 1.35 to 1.4, there is wide

variation in column flexural capacity enhancement (SCWB) factor recommended by various codes (ACI 318 recommends the factor 1.2, Euro code EC08 - 1.35, New Zealand -1.5). To prevent the brittle shear failure NBC/IS also recommends shear capacity factor of 1.4 but are not having any flexural capacity enhancement factor.

In this study five RC framed buildings of different storey numbers have been analyzed using different column overdesign factors. The results are compared as the influence of various SCWB factor over the expected performance of selected RC frame buildings in terms of enhancement in capacity and failure mechanism. With the lower value of SCWB factor insignificant change in capacity curve is observed while gradual improvement is observed with the higher factors. In terms of failure mechanism gradual enhancement from column failure to beam failure is observed but the failure concentration at the bottom storey beam/column is seen even with the higher value of SCWB factor. The effectiveness of alternative method of column flexural capacity enhancement by modified SCWB (MSCWB) was also studied. MSCWB is found to be more effective in terms of enhancement in capacity curve and failure mechanism.

Thesis Title: **SEISMIC VULNERABILITY OF RC FRAME BUILDING IN A CULTURAL HERITAGE SITE OF KATHMANDU**

Submitted by: **Govind Raj Bhatta**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

There are many world heritage sites in Kathmandu valley, their seismic vulnerability study is very important for their conservation. Seismic vulnerability of reinforced concrete frame buildings located in the cultural heritage site Jhatapole near one of the world heritage site Patan durbar square is carried out. The seismic vulnerability of existing buildings due to different earthquake is determined in terms of fragility curves. Limited representative sample buildings are taken for study from the research area. For the modeling and analysis of the buildings material properties and technology traditionally adopted are considered. Capacity is determined from pushover analysis as top displacement by defining formation of plastic hinges for dominant mechanism and linear dynamic response analysis is carried out using ground motion time histories of different earthquakes for response. With the help of capacity and response analytical fragility curves are drawn, using first order second moment method.

One of the major conclusions of the study is the probability of failure, in general, of the studied reinforced concrete buildings lie between 6.16% to 56.99% for peak ground acceleration of 0.3g.

Thesis Title: **SEISMIC PERFORMANCE OF MASONRY INFILLED RC FRAME BUILDINGS WITH SOFT FIRST STOREY**

Submitted by: **Neelam Shrestha**

Supervisor: **Dr. Jishnu Subedi**

ABSTRACT

In earthquake prone region like Nepal, the buildings are the principal structures that are constantly under the risk of possible ground shaking. The rapid urbanization has brought about the pressure in infrastructure construction and as a result to accommodate various functional needs, there has been a rise in construction of open ground storey buildings in urban areas in developing countries like Nepal. The performance of such buildings needs to be assessed in order to safeguard the lives and curtail the economic losses during earthquake.

A typical four storey residential building has been taken as reference model to access the seismic performance of masonry infilled building with open ground storey. Performances of various sets of buildings have been explored by linear static method and nonlinear static methods. The bare frame model, full infilled model and open ground storey model has been analyzed for as built state and designed state (sections obtained after the

seismic design) that has been analyzed and compared accounting the effect of infill walls. As capacity of open ground storey accessed by pushover analysis is unable to meet the seismic demand imposed by IS 1893-2002, some strength increasing options have also been proposed and studied based on codal provision described in IS 1893-2002 and Euro code8. The option for partially infilled walls in ground floor has also been studied by providing infill walls on perimeter and inner core grid.

Based on the result of analysis comparisons have been made for above mentioned models in term of initial stiffness and natural time periods, yield strength and yield roof displacement, ultimate lateral strength and deformation and plastic hinge formation and failure.

One of the conclusion of the research indicate that performance of open ground storey is worse among all cases due to large inter-storey drift and low lateral strength and thus there is an urgent need for retrofitting of such buildings.

Thesis Title: **PERFORMANCE ANALYSIS OF RC FRAME BUILDING WITH IRREGULARITY IN ELEVATION**

Submitted by: **Kritam Maharjan**

Supervisor: **Dr. Jishnu Subedi**

ABSTRACT

Among the various types Of vertically Insular RC IVnmo buildings one of the most prevailing types is stepped buildings. Stopped building frames, with vertical geometric irregularity, are now Increasingly encountered In present urban construction. As these buildings vary in both mass and stiffness along with the vertical geometric irregularity, their irregular behavior should be properly measured and assessed.

For assessing (lie degree of irregularity In a stopped building frame the present study proposed a more rational method of quantifying irregularity m stepped budding, frames, accounting for dynamic characteristics (mass and stiffness). Dynamic analysis was carried out for the common stepped building models. The irregularity of the stepped buildings was quantified by "regularity index" by comparing with the corresponding regular buildings. The values of indices of irregular buildings were less than unity. The study had compared the structural

design parameters like fundamental period and shear force distribution between vertically irregular and regular buildings with same building height. The fundamental period of the stepped buildings were found to be shorter than that of corresponding regular buildings.

Nonlinear static pushover analysis was performed to compute the force reduction factors for the same stepped building frames and was compared with the regular building frames. The study evaluated the force reduction factor "capacity", which is dependent on the ductility reduction factor and the over strength factor. The results showed that there was no significant difference in the values of the force reduction factors between the regular building frames and the stepped building frames.

Thesis Title: **SEISMIC POUNDING EFFECT ON ROW HOUSING**

Submitted by: **Prabin Shah**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

Nepal being seismically vulnerable region, the safety of building is a prime importance among the hazards of possible ground shaking. As a result of rise in population, internal migration etc the construction of row homing is in vogue due to increase in demand of infrastructures in urban areas. Though the biddings mar- be designed to account for credible earthquake event the presence of adjacent structure will affect the dynamic response of both buildings.

The main objective of the study is to assess seismic response of reinforced concrete building that has been constructed with practically no gap with the adjacent structures. For the case study a 5 storey building and 4 storey building with gap of 5 mm, have been considered Nonlinear dynamic analysis is performed using the artificial time history. The combination of linear viscoelastic element and a gap element has been used to simulate the pounding force in buildings. The seismic responses in term of displacement, pounding force and shear response are presented

for both the buildings for the case of pounding and without pounding. Base shear increment factor have been determined by simulating pounding on various sets of buildings. The study of seismic gap using energy approach has been made while the local effect at point of contact is studied by application of distributed plasticity over the finite length of beam.

One of the major conclusions of the study is that the response of flexible building is amplified as compared to rigid one. However a more comprehensive study is required is account for difference in material, model and analysis types.

Thesis Title: **EFFECT OF ECCENTRIC BEAM-COLUMN JOINT AND MODELLING APPROACHES ON PERFORMANCE OF RC-FRAMED STRUCTURES**

Submitted by: **Rabindra Adhikari**

Supervisor: **Dr. Jishnu Subedi**

ABSTRACT

The structural performance of building with eccentric beam-column joint has been evaluated using simplified methods. Various methods are adopted to incorporate eccentricity in the model and the effectiveness of these methods has been evaluated by performing analytical study in a wide variation of models with different eccentricities and storey heights. Since the development of finite element software packages, the speed of design has increased very rapidly. At the same time, people are using it widely, without the proper knowledge of principle on which calculation and design are based on. So, in some instances, some design might not be safe enough if a designer is using the software without proper knowledge if it and its limitations.

From the analysis it is observed that with different methods of eccentricity modelling, though all models seem visually very realistic with all connection at exact location, the building

performances comparison shows no any significant difference between eccentric model and concentric model. However a separate joint model showed up to 20 percent increase in stress in eccentric model. Thus, for analysis where consideration of joint is also to be taken, simplified procedure available in the software may mislead the designer to assume that the model and design is perfect. Hence special precautions should be taken in using these software and features available in them.

Thesis Title: **SEISMIC VULNERABILITY OF MASONRY BUILDINGS**

Submitted by: **Rakesh Dumaru**

Supervisor: **Prof. Dr. P. N. Maskey**

ABSTRACT

Unreinforced bricks masonry structures are vulnerable to earthquake due to their limited seismic capacities. The recorded damage in Nepal reveals the weakness of masonry structures. In view of majority of heritage structures constructed of unreinforced brick masonry in mud mortar and the need of preserving them have motivated to do research in this field so that the possible seismic disaster can be minimized.

The Jhatapole area of Patan was selected as a research site which is one of the historically important places of Kathmandu Valley. Six buildings of different types are selected for modeling in SAP 2000. Building response is carried out by linear time history analysis. The seismic vulnerability of masonry structures is determined in terms of fragility curves which represent the probability of failure damage due to various levels of strong ground motions.

From the research, it is found that the drift is not always maximum at first storey as expected. It is observed that from the

fragility curve, probability of failure is different for different earthquake ground motion time histories although for the same maximum amplitude. Base shear of the respective building is calculated by manual calculation considering average shear stress as 0.078 Mpa for failure mechanism of masonry structures.

One of the major conclusions of the study is the probability of failure, in general, of studied masonry buildings lie between *5%* to 50% for a Peak Ground Acceleration PGA) of 0.3g.

Thesis Title: **SEISMIC PERFORMANCE EVALUATION OF STEEL TRUSS**

Submitted by: **Niranjan Dumre**

Supervisor: **Dr. Rajan Suwal**

ABSTRACT

Seismically, Nepal lies in the most vulnerable region. So, we had experienced many small to large scale earthquakes in the geological history. During these earthquakes infrastructures damaged and fatalism recorded. So it would be injudicious to ignore the effects of earthquakes on the structures. The main purpose of the study is to evaluate seismic performance of steel truss bridge. The dynamic characteristics of Devghatsthal Truss Bridge under the earthquake loading can be obtained by free vibration analysis, response spectrum analysis and Time history analysis (linear and non linear) with different levels of the ground acceleration (0.15g, 0.35g, 0.60g ,1.0g & 2g) in three different axis X, Y, Z respectively. The bridge has been modeled in the most popular finite element software SAP2000. The basic and fundamental parameters to show the behavior of the bridge are Axial Force, Shear Force and Bending Moment. The axial force, moment and shear force capacities have been determined to enable comparison to be made between element capacity and demand. The study purpose of this research is to check to what

extent the bridge could survive under different ground acceleration and to identify the critical part of the bridge. From the bridge overall analysis, it is cleared that the bridge pier is the most critical and susceptible even in low earthquake intensities in horizontal longitudinal direction rather than bridge truss superstructure in case of steel truss bridge and Steel superstructures commonly comprise lighter framing elements: these have been found to be susceptible to damage due to transverse earthquake loading.

Graduation Year 2012

Thesis Title: **EFFECT OF IRREGULARITY IN REINFORCED CONCRETE ON FACTORS FOR VULNERABILITY ASSESSMENT TOOL**

Submitted by: **Bipin Kumar Gautam**

Supervisor: **Dr. Jishnu Subedi**

ABSTRACT

Nepal has experienced several devastating earthquake in the past and is in the danger zone of the seismic map of the world. Due to wrong construction practices and ignorance for the earthquake resistance design of building in our country, most of the existing buildings are vulnerable to future earthquake. The present study deals with the seismic vulnerability assessment of existing reinforced building with different configuration. This study is concerned with the evaluation of the structural strength available behavior factor of existing reinforced concrete buildings. In this study the seismic index of the existing building for different configuration is obtained by seismic evaluation conducted on the buildings.

The buildings are categorized to R, L I , L2, and L3 according to the plan of the building and are analyzed by linear static, linear dynamic and non linear static analysis. During linear analysis, the stress concentration on the ground floor columns are checked and normalized with corresponding base shear. During the nonlinear analysis, The SAP2000 is used for nonlinear analysis and the demand capacity of the different plan buildings is obtained. From the nonlinear pushover analysis, the performance point, yield point, ultimate point of different plan buildings are compared and from these points the strength factor and the ductility factor of buildings are determined. Thus obtained indices are used to determine the seismic index of buildings having different plan. It is found that the index increases with change in shape from R to L3. Similarly, such index is determined by similar analysis for the different aspect ratio of the building. It is found that the index increase with the increase in aspect ratio of the building. Again, buildings are categorized to R, D1, D2, and D3 according to the discontinuity in the lateral load resisting system, that is, discontinuity in column. Similar methodology is used to determine the index for different vertical irregular buildings and for the building having short column due to staircase.

Finally, the seismic index of reinforced concrete building having different configuration is determined. This index is used to recommend the quantitative indicator for rapid assessment of the existing reinforced concrete building for Nepal. Analysis provides the need for strengthen required for particular elements and obtained the seismic index of the strengthen building.

Thesis Title: **SEISMIC VULNERABILITY ASSESSMENT OF REINFORCED CONCRETE BRIDGE WITH MULTIPLE PIER CONSIDERING SOIL STRUCTURE INTERACTIONS**

Submitted by: **Braj Kishor Nayak**

Supervisor: **Dr. Hari Ram Parajuli**

ABSTRACT

This research investigates the seismic vulnerability assessment of Reinforced Concrete Bridge with multiple pier considering soil structure interactions. Bagmati River Bridge at Guheshwori along Gaurighaat to Gothataar sadak in Kathmandu district is used in this research. Nonlinear seismic analysis of soil-well-pier system of a typical bridge supported on well foundation is carried out considering nonlinearity in piers and well. Bi-linear kinematic element is used to model nonlinearity in piers and well. Separation at the interface of soil and well is considered using compression-only gap elements. A series of time domain, inelastic finite element simulations of seismic behavior of a bridge pier subjected to various earth-quake events is carried out. The model incorporates SFS interaction through the use of equivalent springs. The spring properties are derived from three-dimensional finite element analysis of the well foundation in a

layered soil system. Substructure- Superstructure connection has been modeled as to represent real force- displacement characteristics considering capacities of individual elements in the direction under consideration. The bridge pier capacity has been assessed using pushover analysis. The maximum possible displacement of super structure and the maximum incidental loading on the bridge pier corresponding to different seismic loading has been assessed using Time History analysis. The result from Time history analysis and push over analysis has been used to identify the damage states of individual components of bridge.

At last, recommendations for retrofit measures to anticipated failure condition of bridge corresponding to maximum considered earthquake has been made.

Thesis Title: **ANALYSIS IF SHEAR BEHAVIOR OF REINFORCED CONCRETE BEAM-COLUMN JOINT SUBJECTED TO EARTHQUAKE LOADING**

Submitted by: **Bishow Kumar Shrestha**

Supervisor: **Prof. Dr. Hikmat Raj Joshi, Mr. Siddarth Shankar**

ABSTRACT

In the Reinforced Concrete Moment Resisting Frame (RCMRF) Structure, beam- column joint is the weakest zone during earthquake. Failure of joint region may lead to the complete collapse of Structures. The behavior of joint during earthquake is influenced by many parameters. This study has attempted to investigate the shear behavior of joint and its influencing parameters in terms of stiffness and crack pattern. The joint of typical four-storey building were studied under multistep loading. The finite element model of joint has been prepared on ANSYS 12.0. The concrete is modeled by SOLID65 element which has capability of cracking in three orthogonal directions in tension, crushing in compression, plastic deformation and creep with three degrees of freedom. The reinforcement is modeled with LINK8 element which has capability of plastic deformation with three degrees of freedom. Discrete modeling of

reinforcement has been done. The boundary conditions on the model are so produced so that the model will represents like an experimental model.

The joint shear behavior has been identified by five points on lateral load vs. displacement curve. Label 1 represents the initiation of flexural cracks on the framing beams, Label 2 represents the initiation of diagonal cracks on the framing beam, Label 3 represents the initiation of cracks on the joint region, Label 4 represents Yielding of reinforcement and Label 5 represents Collapse state. The parameters that control the shear behavior of joint has been identified as Concrete compressive strength, joint shear reinforcement, column axial load, column longitudinal reinforcement, beam longitudinal reinforcement. It has been found that interior and exterior beam-column joint with all parameters same, the exterior joint has less shear capacity than the interior joint.

Thesis Title: **SEISMIC RESPONSE OF SHEAR WALL STRUCTURE WITH OPENINGS**

Submitted by: **Debendra Dev Khanal**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT

Nepal is seismically vulnerable, most losses of lives in the past earthquake in developing countries have occurred due to collapse of buildings. The high rise buildings with shear wall are popular choice because of seismic resistant and cost effective too. The existence of the opening in shear wall is for various purposes such as windows, doors or according to the architectural aspect desired by owner.

The study investigated the accuracy of a continuous medium method in evaluating the stiffness and determined the seismic responses of buildings with openings in shear wall. The effect of size and configuration of openings in shear walls has been studied in terms of displacements, base shear and fundamental time periods due to static load cases as per IS 1893 (part I): 2002 and response spectrum cases on different storied shear walls varying from sixth storied to eighteenth storied with different horizontally and vertically centered openings. The analysis was performed using FEM based software SAP2000 vl4. The results

reveal that the stiffness as well as the seismic responses of the wall is more affected by the size and location of openings. It was found that the increase in size of opening also increases the top deflection and maximum principal stress while, the base shear decreased. By comparing the stiffnesses of sixth, twelfth and eighteenth storied rectangular shear walls of different base length with different opening sizes the difference of stiffnesses obtained from the continuous medium and finite element methods was found less than 10% with opening area of 14% to 42% at the base of shear wall if the base length to height ratio is about 0.27, if the ratio decreases to 0.18 the difference was 60% for 14% opening and 32% for 35% opening. The result showed that the opening arrangement in shear wall has significant effects on the stiffness of the system, when the opening area in the shear walls is larger.

Thesis Title: **SEISMIC PERFORMANCE EVALUATION OF REINFORCED CONCRETE ARCH BRIDGE**

Submitted by: **Jeena Dangol**

Supervisor: **Dr. Rajeev Suwal**

ABSTRACT

The entire Himalayan belt, because of its active tectonic movement, is seismically active causing high risk of earthquake in that region. Nepal lies at the very central part of the active Himalayan belt and therefore is vulnerable to disastrous earthquakes. Hence it would be imprudent to ignore the effects of earthquake on the infrastructures. Among 200 countries, Nepal ranks 11th with regard to vulnerability to earthquake as per UNDP 2004. As such, it is important to evaluate the seismic performance of the structures to identify to what extent they would survive during earthquake. Bridges are lifeline systems, these must remain functional even after earthquake since their damage and collapse not only cause loss of life and property, but also weigh down the post-earthquake rescue operations. Therefore, seismic resistant design and construction should be incorporated to the bridges. Those which have already been constructed should be assessed for their seismic capacity.

In this research, the seismic performance evaluation of a reinforced concrete arch bridge located in Chobhar, Nepal has been conducted. A finite element model of the study bridge is prepared in SAP2000. The seismic input is taken as five different earthquake ground motion histories having different V/H peak ground acceleration ratio for time history analysis. Displacement capacity of the bridge has been determined from pushover analysis. Time history analysis is conducted in two different steps: first only horizontal acceleration is applied and next vertical acceleration is applied in addition to horizontal ground motion. Comparisons are made between the responses of the bridge for these two cases. Variation of axial force and bending moment on arch rib and spandrel column for varying V/H ratio are also evaluated.

Thesis Title: **SEISMIC PERFORMANCE EVALUATION OF BRICK MASONRY STRUCTURE**

Submitted by: **Kaushal Ghimire**

Supervisor: **Mr. Hari Darshan Shrestha**

ABSTRACT

Masonry structures are widely used due to its tow cost and construction easiness especially in countries like Nepal. One of the studies made by JICA in 2002, states that brick masonry building built in past 20 to 10 years consists of more or less half of the building in the valley. These building are considered to be very poor to resist the earthquake force. Study in brick masonry is helpful for predicting its performance and take necessary action.

Low rise unreinforced brick masonry structure with concrete slab is studied in this work. Performance of three brick masonry building is compared by developing fragility curves in different damage state. Among three brick masonry structure, one represents building constructed according to guideline of building code. Second building represents local building and third building is same as local building (second building) but changing its criteria according recommendation given by

building code of Nepal. Seismic capacity in terms of displacement is find out and fragility curves at different limit damage states is develop by performing time history analysis in SAP2000 V14. The result shows that local building is more vulnerable to the seismic action in comparison to other two which were constructed as per recommendation given by building code.

Thesis Title: **EVALUATION OF OUT-OF-PLANE RESPONSE OF INFILL BRICK MASONRY PANEL WITH R/C BANDS**

Submitted by: **Kuber Bogati**

Supervisor: **Mr. Hari Darshan Shrestha**

ABSTRACT

The construction of brick infill wall is a common practice these days, moreover the local government authorities has implemented the Nepal National Building Code (NBC) and hence almost all non-engineered buildings constructed under NBC 201: 1994, is constructing brick infill wall monolithically with RC structural bands in order to enhance the out-of-plane capacity of the wall, and there is lack of numerical study concerning the provision made, viewing this prime gap, the research has been initiated. Extensive non-linear numerical simulations have been made using Applied Element Method. This method can follow the behavior of structure since the load application, crack initiation and propagation, separation of structural elements and until total collapse can be done in a reasonable time with reliable accuracy. In AEM, a given structure is divided into a proper number of rigid body elements connected with pairs of normal and shear springs uniformly distributed on the boundary line.

The study concentrates on brick infill frame panels with and without RC structural bands considering openings at different locations and without openings. Opening include window. Also to study the effect of slenderness ratio of standing wall on out-of-plane failure, different standing wall with varying slenderness ratio has been studied.

Thesis Title: DEVELOPMENT OF SEISMIC HAZARD MAP OF NEPAL

Submitted by: Nabin Paudel

Supervisor: Prof. Dr. Hari Ram Parajuli

ABSTRACT

The present study is focus on Probabilistic seismic hazard assessment of Nepal which is lies on geological boundary of 26° 22' E to 30° 27' E latitude and 80°04'N to 88° 12'N longitude. Review of available information on tectonic setting, seismicity and attenuation of peak ground acceleration of Nepal has been done. The earthquake catalogue has been prepared by assessing different references. The Recurrence relation has been developed by using Gutenberg-Richter (G-R) relationship. The entire area of Nepal has been divided into 1° *0.5° grid size on longitude and latitude and hazard assessment has been carried for each node of these grids by considering the seismicity within 300 Km radius. Three Attenuation model derived for the subduction zone was selected and given the equal weight to calculate the mean rate of exceedence of peak ground acceleration (PGA). The response spectra of major cities and places for various period of vibration are plotted for 40%, 10% and 5% probabilities of exceedences. The distribution of peak ground acceleration over and on the periphery of Nepal for return period of 100, 475 and

975 are plotted and presented as contour for peak ground acceleration.

Thesis Title: **SEISMIC RETROFIT OF CIRCULAR BRIDGE PIERS BY STEEL JACKETING BASED ON FRAGILITY ANALYSIS**

Submitted by: **Pradeep Bhandari**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT

Most of the bridges in Nepal that were constructed following old IRC codes (with little or no seismic consideration) are still in use and play important roles in our transportation systems, which may be susceptible to damage due to their structural deficiencies during earthquakes. So, it has been necessary to evaluate the seismic vulnerability of bridges and strengthen them if needed.

Analytically obtained fragility curve is one of the popular tools in seismic vulnerability evaluations of bridge piers. In this research, analytical fragility curves of bridge before and after retrofit by steel jacketing are developed considering nonlinear behavior on bridge pier's plastic zone only and all other components acting linearly using first order second moment method (FOSM). The generated fragility curves of as built bridge showed that, for seismic hazard level 10% probability of exceedance in 50 years the bridge pier has probability of failure 80.58%, 52.64%, 12.83% and 4.67% corresponding to slight,

moderate, extensive and complete damage respectively. Similarly, for the same hazard level, the probability of complete damage of as built, retrofitted with steel jacketing of thickness 6mm, 10mm and 12 mm bridges are 4.67%, 0.03%, 0.004% and 0.002% which showed the excellent performance after retrofit. Using fragility analysis, for retrofit of bridge under study, steel jacketing of 10 mm thickness is found to be appropriate which satisfies the acceptable probability of damage. This study shows that the fragility analysis can be used for selection of optimal retrofit option.

Thesis Title: **SEISMIC ANALYSIS OF REINFORCED CONCRETE BRIDGE UNDER MULTIPLE SUPPORT EXCITATIONS INCLUDING COMPARATIVE STUDY SIMPLY SUPPORTED AND CONTINUOUS BRIDGES**

Submitted by: **Pradip Paudel**

Supervisor: **Mr. Siddarth Shankar**

ABSTRACT

Bridges are lifeline structures. They act as an important link in surface transportation network. Engineers and researchers have long recognized the importance of vehicle- induced vibration and earthquake induced vibration with regard to the response and service life of bridges. Failure of bridges during a seismic event will seriously hamper the relief and rehabilitation works. Bridges are particularly vulnerable to damage and even collapse when subjected to earthquakes due to their structural simplicity. Nepal lies in seismically vulnerable zone and since concrete bridges are widely used, it is necessary to study the response of those bridges components during earthquakes.

In this paper, multi-point excitation of concrete bridge is determined by using Time History Analysis (Modal Time

History and Direct Integration), in the concrete bridge, the earthquake wave passage effect is considered as the time lag between two supports of the bridge. The soil-structure interactions and incoherence effects are discarded but the standard Shear Wave Velocity is used for soft soil.

While designing bridges-deck, placing of the live load become quite tedious for different class of loading. Comparison of Simply Supported and Continuous Bridge using Moving Load Analysis is done for 10m to 30m span bridge. The impact factor on these loading is not considered as the same that can be applied on the final calculations. Finally, charts are prepared to obtain and compare the design forces for various load cases enumerated as per IRC loading for Simply Supported and Continuous Bridges.

Modeling of bridge is done using line and shell elements for different component of bridges using SAP2000vl4, vl5. For acceleration-time history analysis, Kobe Earthquake Records are used. Significant differences in dynamic response of the bridge are predicted considering the multiple support excitation and uniform support excitation.

Thesis Title: COMPARATIVE STUDY OF ULTIMATE CAPACITY OF THE RCF FRAMED STRUCTURE

Submitted by: Sabin Singh

Supervisor: Dr. Jishnu Subedi

ABSTRACT

Ultimate capacity of the structure is the maximum base shear that the structure can resist the given load. This ultimate capacity of the structure can be found by the capacity curve using Pushover Analysis. Three models having different number of storey are adopted for the analysis. These buildings are first design according to the code. A default hinge for the frame elements are used for the analysis. There are different frame element parameters that can effect to the ultimate capacity of the structure.

With the variation to the structural element for the ultimate capacity, it was observed that, with the increase in the column reinforcement, beam reinforcement and column size, the ultimate capacity of the whole structure will increase for the number of storey. There is no any significant change to the ultimate capacity of the structure with the change in the beam size. It is also observed that for certain percentage of reinforcement the ultimate capacity is constant but with the increase in the column

size and beam reinforcement this ultimate capacity can be further increased.

Thus, to increase the ultimate capacity of the structure, column reinforcement is to be increase but to the certain reinforcement the capacity is constant and to increase further capacity, beam reinforcement and column size may be increased. This shows, there is also importance of the beam reinforcement to increase the ultimate capacity of the structure.

Thesis Title: **SEISMIC PERFORMANCE EVALUATION AND STRENGTHENING OF REINFORCED CONCRETE WATER STORAGE TANK**

Submitted by: **Sudeep K.C.**

Supervisor: **Dr. Jishnu Subedi**

ABSTRACT

Nepal lies in one of the most seismically active region. So, seismic safety of any structure is of most considerable important. Elevated water tanks are one of the most important lifeline structures. Elevated water tank forms an integral part of water supply scheme in many cities. This structure has large mass concentrated at the top of slender supporting structure. Hence these structures are especially vulnerable to horizontal force due to earthquake.

Thus, this study is carried out. The main objectives of this study are to evaluate the performance of existing elevated water tanks subjected to possible sever ground motion due to earthquake considering fluid structure interaction and to assess the relative performance of various retrofit methods.

The seismic performance of water tank is evaluated using linear and non linear analysis in SAP 2000 for different cases. Based on the seismic evaluation, retrofit techniques such as concrete jacketing of structural member, addition of external steel bracing and addition of shear walls are applied to enhance the seismic performance of the structure;. The retrofits are selected to impact the major structural response parameters such as stiffness, strength and ductility. Concrete jacketing is applied on column and beams in all four sides. External steel bracings and shear walls are added concentric in between the panel of existing frames. And nonlinear static analyses are performed to predict the seismic behavior of the retrofitted structure. Based on the analytical results, it is found that concrete jacketing increase strength and stiffness of structure while steel bracing and shear wall contributes to the structural stiffness and reduces the maximum drift of the structure. These retrofit techniques are found significantly enhancing the seismic performance of structure.

Key Words: Seismic performance, Strengthening

Thesis Title: **DEFORMATION ANALYSIS OF KULEKHANI-I DAM UNDER EARTHQUAKE EXCITATION**

Submitted by: **Sunder Shrestha**

Supervisor: **Dr. Hari Ram Parajuli**

ABSTRACT

The purpose of this study is to analyse the behaviour of the Kulekhani Dam. This study is mainly focused on the crest deformation of the dam. This research is also focused in the study of the variation of the result with the variation in the parameter of the core-shell interface. In the present research this non-homogenous nature is addressed in term of different material properties of the different layers of the rockfill dam as the rockfill dam is made of locally available materials which may be non- homogeneous but the consideration of this fact is out of the scope of this thesis. Comparative analysis between the dams with links and gaps and dams without the consideration of these elements were done. Finally, the permanent settlement of the crest is calculated by dynamic analysis utilizing the chart developed based on Newmark's analysis procedures. For the static analysis, free vibration analysis and the time history analysis SAP 2000 v14 is used. The recorded N-S and E-W acceleration components of the famous Imperical Valley

earthquake of May 18, 1940 (El Centro, California, USA) are taken as the prescribed input ground motion. Linear direct integration time history analysis is adopted. The flexible foundation model is adopted for the analysis process based on the stress criterion. For calculating the hydrodynamic added mass Westerguaard's formulation of added mass is used in case of the dynamic analysis.

Thesis Title: **RESPONSE REDUCTION OF RC BUILDINGS**

Submitted by: **Utsav Katwal**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT

It would be uneconomical to design a structure to withstand the greatest likely earthquake without damage because earthquake cannot be predicted with respect to time and magnitude rather structures could be designed as ductile structures so that the energy can be absorbed and dissipated by inelastic deformations. One of the important factors which affect design is Response Reduction Factor which is a value by which the effect of actual intensity of earthquake on structures is reduced. It has been widely accepted that the Response reduction factor depends on ductility, overstrength, structural redundancy and damping associated with structure. The objective of this work is to evaluate and compare response reduction factor, overstrength factor and ductility factor for RC buildings supported on framing system with different configuration varying geometrical and material properties. Another objective of the study is to propose an approximate empirical formulation depending upon various parameters of building. Nonlinear static pushover analysis was performed to compute the capacity curve from which ductility

and overstrength factor were determined and finally response reduction factor was determined. One of the major conclusion is that response reduction factor is comparatively high for regular buildings compared to irregular buildings.

Thesis Title: **SEISMIC PERFORMANCE ASSESSMENT OF HIGH RISE BUILDINGS WITH THE EFFECT OF MASONRY INFILL**

Submitted by: **Niranjan Shrestha**

Supervisor: **Dr. Hari Ram Parajuli**

ABSTRACT

The construction of reinforced concrete buildings from ten to twenty floors in Kathmandu valley has lifted up few years back due to the high cost of land and other increasing living facilities in vertical living. In almost all such buildings masonry infill constitute a large part especially as creating partition; however, the design practice ignores the effect of this stiff masonry infill. So, the performance of such buildings considering the effect of infill wall should be known. The effects of infill panels on the response of R.C frames subjected to seismic action are widely recognized and numerous experimental investigations as well sis several analytical models have been developed on this subject. This study focused on the use of multi strut model for the infill wall. In order to know the performance of building, drawings were collected from DUDBC, Kathmandu, which were approved for the construction. Two building models were prepared, one with the aspect ratio of 1.02 (lowest among the collected

drawing) and the next with aspect ratio of 2.25 (highest among the collected drawing) in SAP 2000 for the non-linear static pushover analysis. The infill wall were modeled as a equivalent diagonal struts (3 compression struts) considering the effect of opening. Comparison of the result of analysis obtained showed that the base shear capacity increase sufficiently with the introduction of struts and the excessive crack were found in wall panel before the collapse level hinge formation in RC members, which questions on the consideration of non-structural damage in designing of the buildings. Also, the force reduction factor was calculated which, showed that with the introduction of strut, ductility factor decreases whereas over strength factor increases and finally the force reduction factor is slightly reduced in strut model than that in the bare frame model.

Thesis Title: **EFFECT OF SOURCING OF PIER FOUNDATION ON SEISMIC RESPONSE OF BRIDGE STRUCTURE**

Submitted by: **Rupendra Bar Dhoj Thapa**

Supervisor: **Prof. Dr. Prem Nath Maskey, Mr. Mohadatta Bhatta**

ABSTRACT

Bridges are very important structure and play important role during an earthquake for the evacuation of people as well as in the post earthquake events. Bridge is the critical lifeline that is directly related to community. In earthquakes, bridges did not perform well, showing an increased need of research and understanding of different potential problems and collapse mechanisms.

The RCC pier with well foundation at the middle of the bridge located at Bangari Khola has been studied. The considered bridge is vulnerable to the scouring effect though the river belongs to the catchments of with loose soil and week geology.

Altogether, 153 models have been prepared with SAP2000 for analysis at different cases idealization. Each spring represents 0.5m thick soil. The pier and foundation has been modeled as a

linear elastic frame element, and Winkler springs model has been adopted. The superstructure mass has been lumped at pier top. The linear elastic time history analysis (direct integration) is performed using El Centro Earthquake data.

The peak lateral displacement of the top of pier due to scouring is the concerned of this study. The effect of scouring on seismic response is determined and represented in term of peak lateral displacement of pier top versus fraction of scour depth can be generalized as $y=0.486e^{807x}$ that is limited to 0.78H. Analysis result demonstrates that the displacement is the function of modulus of subgrade reaction and the geometry of the foundation that increases as the scouring increases; increases as the superstructure load increases; and decreases as the length of well increases. The displacement of piers increases with very small value until the center of mass is below the ground level and the increasing rate enlarges rapidly when exposed due to the change in frequency. The mass of the infill soil in well to increase the self weight of the foundation also contributes for the increase in inertia of motion. The optimum value of displacement attains when the exciting frequency equals to the frequencies of corresponding modes of vibration structure (i.e. resonant response, P=l). The multiple peak of the curve is due to different modes of vibration. The shifting of the optimum displacement towards the lower fraction of scour depth at different case is due to increase in cantilever mass there by decrease in frequency.

Thesis Title: **PERFORMANCE ANALYSIS OF BRICK MASONRY BUILDING**

Submitted by: **Subin Desar**

Supervisor: **Dr. Jishnu Subedi**

ABSTRACT

Masonry is the composite material composed of brick (or stone) with cement mortar, The performance analysis of masonry is complicated task as it is non-homogeneous material and its properties depends upon many parameters like properties of its ingredients direction of applied forces amount of cement and sand used etc. Further, for the performance evaluation of masonry it is not adequate just only to concentrate on the components of the masonry. The strength of masonry also depends upon external condition like, the foundation condition on which it rest. For the verification, the modelings of the masonry structures are done in SAP 2000v. 14.0,0 Comparison was done with the experimental values and conclusions drawn out. The results obtained arc further verified with its application in the existing buildings.

Thesis Title: PERFORMANCE ANALYSIS OF MASONRY IN-FILLED NON DUCTILE RC FRAME STRUCTURES

Submitted by: Rajendra Acharya

Supervisor: Dr. Jishnu Subedi

ABSTRACT

Nepal lies in one of the seismic prone zone. It is the country lying between the northern Tibetan pate and southern Indian plate. Indian plate is sub ducting into the Tibetan plate by 4 inch every year. Because of this tectonic movement, the Himalaya is one of the active seismic belts on the globe. This subduction is accumulating tremendous amount of the strain energy. After certain capacity limit of the material forming these plates release this accumulated energy. This sudden release of energy may bring most devastating earthquake.

In this research seismic performance analysis of masonry in-filled RC frame structure with different infill conditions is carried out. The performance analysis is carried out by linear time history and Non linear static Pushover analysis. In Linear time history analysis, the responses of the all the building in terms of absolute acceleration is investigated. The peak response of the structures varied along their stiffness value. The peak

response is found nearly at the time period of building. From Non linear static pushover analysis the sequential failure of the structural member is studied. As the hinges are formed in the structure the stiffness found to be degraded and correspondingly the effective time period of all the models is observed to be increased.

Thesis Title: **EFFECT OF VARIATION OF PIER HEIGHT ON THE FRAGILITY OF REINFORCED CONCRETE BRIDGE PIERS**

Submitted by: **Raghabendra Yadav**

Supervisor: **Prof. Dr. Prem Nath Masky, Mr. Mohadatta Bhatta**

ABSTRACT

Earthquake is the major natural hazard in Nepal. The operability of the highway network after earthquake is extremely important. Bridges are one of the main components of highway networks. Bridges should be functional before and after earthquake for emergency services.

In this research, seismic response of different height reinforced concrete bridge piers excited by different ground motion time histories are obtained. The capacities of different height reinforced concrete Bridge piers are found out and analytical fragility curves for each are developed using First order second moment theorem.

The probability of exceeding slight damage with pier height 9m, 11m, 13m, 15m, 17m, 19m and 21m are found as 9.43%,

13.46%, 15.36%, 16.97%, 20.49%, 23.0% and 24.77% respectively for earthquake intensity 0.3g. The probabilities of failures of bridges are increases with the increase in the pier height of the bridges.

Thesis Title: DYNAMIC ANALYSIS OF STONE MASONRY BUILDING

Submitted by: Jhanka Bahadur Thapa

Supervisor: Prof. Hari Darshan Shrestha

ABSTRACT

The objective of proposed research work is to evaluate the seismic performance of the masonry building which are basically with stone masonry for future earthquake. Three typical types of stone masonry building were modeled and analyzed using shell and area element in SAP 2000 software. Analysis is performed using Linear Time History Analysis. The seismic vulnerability of masonry structures is determined in terms of fragility curves which represent the probability of failure damage due to various levels of strong ground motions. Two types Fragility curves are obtained; one represents the probability of failure of whole building and another represent the probability of wall panel of the masonry building. Base shear of the respective building is calculated by manual calculation considering average shear stress as 0.053Mpa for failure mechanism of masonry structures.

Response of the typical types of stone masonry buildings to different earthquake time histories in terms of storey displacements, base shear and in plane shear stress (shell stress)

is found out. The results show that the stone masonry buildings are seismically vulnerable. One of the major conclusions of the study is the probability of failure of the wall panel is so greater than the probability of failure of the building for different Peak Ground Acceleration (PGA). And the section above the openings of stone masonry is the most critical part for shear failure. In general the probability of failure in terms of base shear is lower than the probability of failure in terms of wall panel for same value of PGA.

Thesis Title: **SEISMIC PERFORMANCE OF BUILDINGS WITH VERTICAL SETBACK**

Submitted by: **Biva Shrestha**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT

Even though it is a fact that irregular and asymmetric buildings have poor performance during earthquakes, multitude of reasons like appealing aesthetic appearance, consumers' requirement, constraints in availability and high economic value of land result in the construction of buildings which deviate from traditional concept of symmetry and regularity. On regard of the irregularity, vertical irregularity comprising of setback buildings is one of the form which is often constructed in present context. So this study focuses on evaluation of buildings with setback at different level and compares their response with reference to regular building.

Seismic response of buildings in terms of modal characteristics, displacements and interstorey drifts are evaluated using seismic coefficient and response spectrum methods. Setback buildings show decrease in time period. Higher mode effects also increase as setback level is increased which is contrary to regular

buildings in which first mode always dominates the response. Increase in displacements occurs for increase in setback level. Interstorey drift are seen to decrease in storey lower to setback level and increases in storey above setback level.

Response reduction factor "R" which is a vital factor in force based seismic design of structures, the assignment of value for which is based on engineering judgment and past records is also systematically evaluated. Value of R obtained for regular building is comparable with values assigned to R for different codes like EC-8, UBC-97 and IBC-2003 and result shows that IS 1893 (Part 1):2002 value for R is conservative. The value of R for setback buildings show decrement when compared to value of R for regular buildings justifying that R value should be different for different types of building with respect to irregularity and asymmetry.

Graduation Year 2013

Thesis Title: **COMPARATIVE STUDY OF RCC T-GIRDER BRIDGE WITH DIFFERENT CODES**

Submitted by: **Mahesh Pokharel**

Supervisor: **Prof. Dr. Hikmat Raj Joshi**

ABSTRACT

Standards and codes are being updated continuously, and we have seen a flood of new codes and standards in the past few years. But to fit into and place them, we must first understand their impacts. Although there have been noteworthy advancements in design and modeling of structure in the recent years, there is always much place for improvement.

There are different highway bridge design concepts and standards used in different countries. In the highways of Nepal, different bridges are found designed based on different standards. Many of the bridges have been designed based on IRC and AASHTO standards. Nepal Road Standard (NRS 2027) has adopted these two standards for highway and feeder roads. In this thesis some well-known codes are reviewed in detail for a survey of current code requirements and common practices under bridge design in several countries including India, United States and European Countries. By comparing code philosophy and detailed codified design procedures in these countries, similarities and differences in various parameters become apparent. This thesis discusses the seismic design and analysis of bridge structure subjected to load with three codes namely: Indian Road Congress code, AASHTO LRFD code, and Euro Code with observations in Highway loadings of Nepal for the typical bridge. The study is focused on the loading pattern, design and overall analysis of bridge components with the three codes. The results discuss the cost effectiveness of codes that the number of reinforcement bars in the design with same dimensions. Required dimensions and reinforcements of the bridge are calculated depending on the data collected from the typical bridge. The maximum values of the design parameters are compared in a relative way. AASHTO LRFD code gives maximum bending moment in girder by 23.2% larger value and Eurocode gives 68.5% larger value than IRC code. Similarly, in the case of maximum shear force, AASHTO LRFD gives 24.8% less and Eurocode gives 32.6% larger value than IRC code. Eurocodes are made for wide range of applicability and coverage so it can be referred for the design of bridges in Nepal also. Nationally determined parameters can be developed further for suit of Nepal also.

Thesis Title: **SEISMIC VULNERABILITY EVALUATION OF REINFORCED CONCRETE MULTI- COLUMN BRIDGE PEIR**

Submitted by: **Subash Bastola**

Supervisor: **Dr. Rajan Suwal**

ABSTRACT

Nepal is highly susceptible to imminent seismic hazard. Road network is the key transportation infrastructure of Nepal. As bridges are indispensable component of road network, it is rational to demand that they need to remain intact after earthquake in order to facilitate rescue and restoration activities. There is perpetual effort to reform codal provision for seismic analysis and design of structures. Unfortunately, in Nepal we have practice of conservative seismic design without rigorous analysis. There are practices of Multi-column pier bridges in various parts of Nepal which are of course in need of seismic assessment.

In this research it is intended to assess seismic performance and vulnerability of reinforced concrete multi-column bridge piers designed and constructed following conventional ways prevalent in our current practices in Nepal. A typical bridge having multi

column pier is analyzed using SAP2000 vl4.0.0. Displacement capacity of bridge pier is determined by pushover analysis. Also the performance of individual pier is investigated. It is found that the moment and shear contribution is higher in extreme pier in the direction of push and the tensile reinforcement in first pier (push direction) yields before other piers. Further the damage sequence in individual pier is carried out with the definition of HAZUS MH MR3 (2003) which showed that the extensive and complete damage states are governed by the extreme pier in push direction. The response of reinforced concrete multi column bridge pier is calculated using linear and nonlinear time history analysis for earthquake loading in transverse direction. The fragility curves for different damage states are derived from response 9 and capacity analysis of the bridge piers using first order second moment (FOSM) method. Thus seismic vulnerability of the existing bridges can be quantified with the help of fragility curves. The curves when read along with seismic hazard map of bridge location will provide the probability of failures for different damage states.