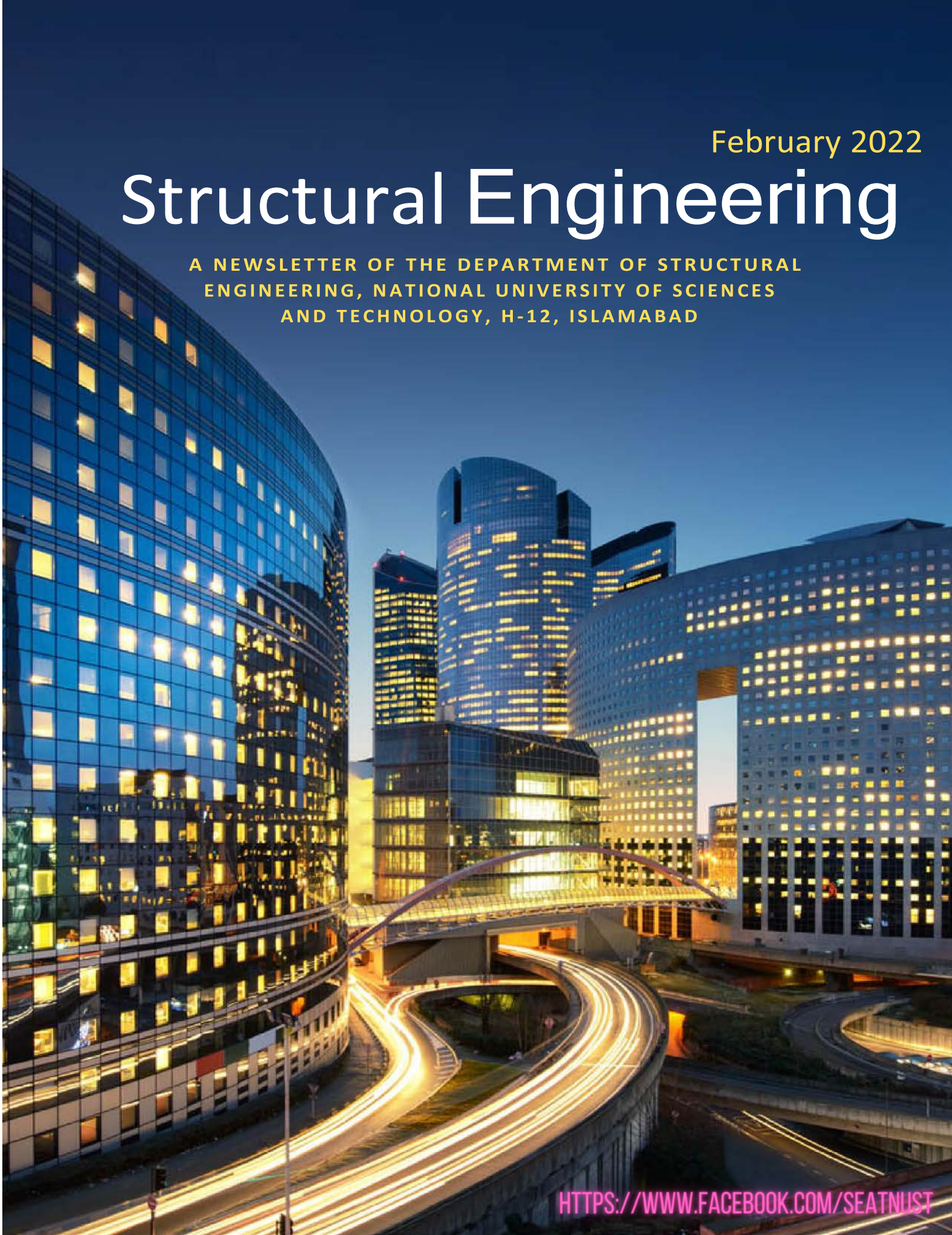
February 2022

Structural Engineering

A NEWSLETTER OF THE DEPARTMENT OF STRUCTURAL ENGINEERING, NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY, H-12, ISLAMABAD



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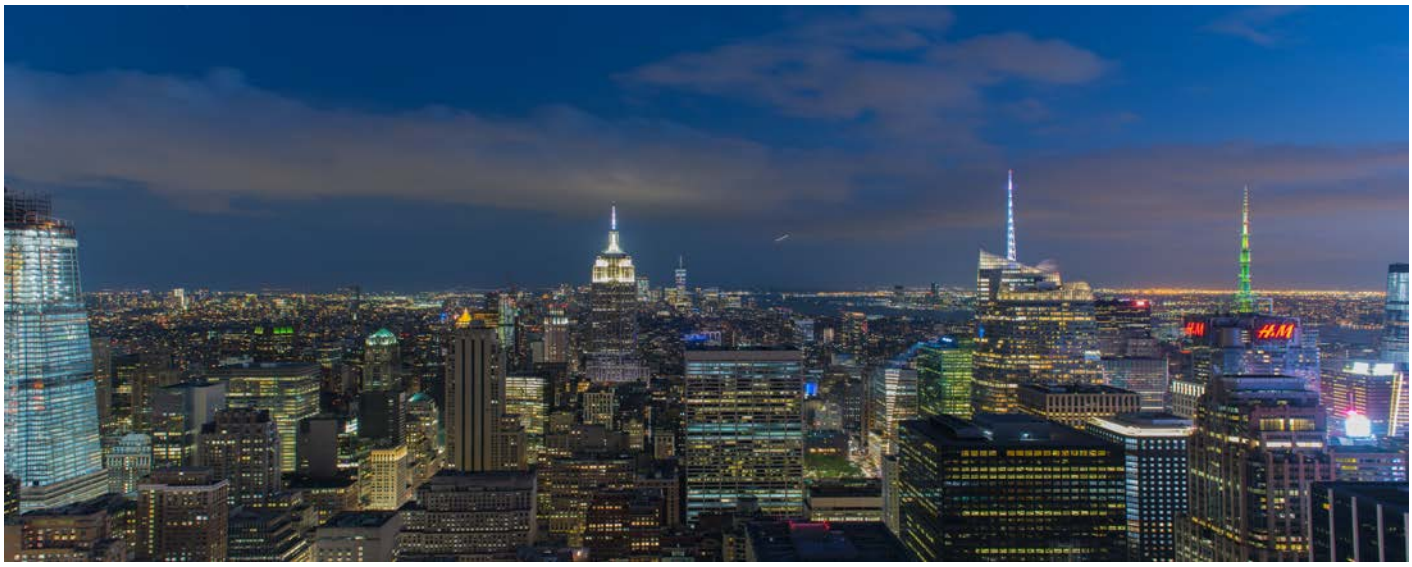
Structural Engineering @ NUST
National University of Sciences and Technology
Islamabad, Pakistan

NUST Institute of Civil Engineering (NICE), School of Civil and Environmental Engineering (SCEE), National University of Sciences and Technology (NUST), Sector H-12, Islamabad, Pakistan

Department of Structural Engineering Newsletter

FEBRUARY 2022, Number II



INSIDE THIS ISSUE

NUST
NATIONAL UNIVERSITY OF SCIENCES & TECHNOLOGY

DEPARTMENT OF STRUCTURAL ENGINEERING NEWSLETTER

Call for Contributions

Become a part of the latest Issue

Faculty members, students and alumni are invited for the submission of

- Ideas, research topics and ongoing projects
- News items, conference items, etc.
- Brief articles – short, topical, news-oriented
- Award recognitions

Guidelines

- All articles must be submitted in Word format and include a title.
- Photos, images, or graphics are encouraged, and may be resized for placement.
- Please include links (URLs) to additional information.
- Word count:
  - News items, Affinity Group reports, and announcements – 50 to 200 words
  - All articles have a limit of up to 500 words.

Deadlines and Queries

The deadline for the submission of mentioned topics is 30/05/2022. Submissions after the deadline will not be accommodated.

For further queries, contact us

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Editorial Board

RESEARCH AT GLANCE YEAR 2021

Bio Encapsulated Steel Embedded Concrete with Enhanced Immunity for Corrosion

Sajid Rasheed

Supervisor: Dr. Rao Arsalan Khushnood

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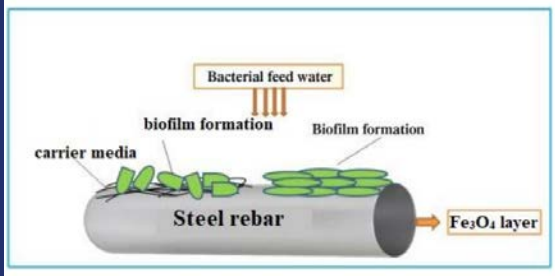


Main Goal:

Corrosion is most highlighted issue of reinforced concrete and major concern of construction industry. It is vulnerable for the climate due to reduction of structural age and new construction demand and giant impact on economy. The repairing of reinforced concrete structure is not possible that leads to 90% demolishing of structure victimized by corrosion. Under environmental actions, micro-cracks produced in the concrete provide pathways for aggressive substances to penetrate and cause corrosion of the embedded steel, hence destroying the strength and durability of concrete structures.

Methodology:

Several suggested solutions associated to this problem are limited to some extent due to side effects and economical restrains. In this study biological addition is suggested as a solution for corrosion inhibition. Incorporation of bacteria into concrete along with micro-nano materials precipitate CaCO3 which helps to patch the microcracks.

Bacillus subtilis and Escherichia coli bacteria, being alkaliphilic, higher spores forming and having longer survival in dormant stage, were immobilized in micro-nano materials. Where micro-nanomaterials selected as carrier media were nano-micro particles of iron oxide and zeolite that were further modified in their properties and magnetized under Holtzman coils and then tested for magnetic saturation by VSM apparatus. Biofilm of bacteria and then bacteria with carries medium is formed and then embedded in concrete.

Bacteria like Bacillus Subtilis, when added to an optimum concentration, sustained in concrete and compressive strength improvement are reported after 28 days. (Sandip Mondal et al. 2017). Addition of Bacillus Subtilis imparts pore refinement and dense concrete matrix obtained due to microbiologically induced calcite product. (Shradha Jena et al. 2020).

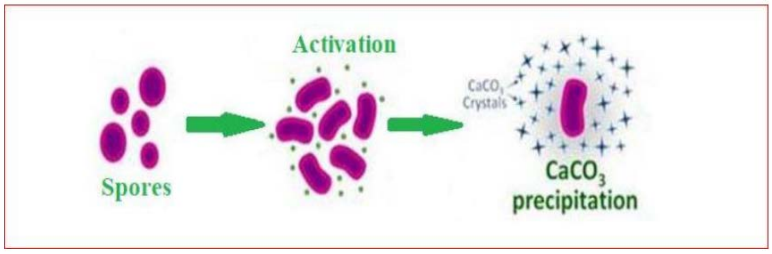


Figure 1.4: Precipitation of calcium carbonate by bacteria

Conclusion:

Enhanced the properties of carrier medium by applying heavy magnetic field for iron oxide nano-micro particles and ball milling for zeolite nano-micro particles that support in formation of dense and thick biofilm on the steel metal surface.

Precipitation of biofilm by bacteria on steel rebar

- Biofilm was formed successfully, iron oxide with bacillus subtilis and E. coli developed 40 micrometer thick biofilm around the steel rebar, which was analyzed qualitatively and quantitatively by XRF, FTIR, SEM, volumetric analysis, weight gain analysis and profilometry.

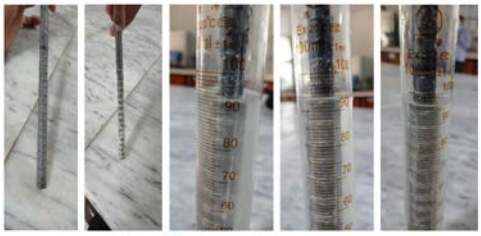
- Biologically encapsulated steel embedded concrete showed 78.5 % corrosion inhibition efficiency, 998 Ω polarization resistance and corrosion rate was reduced 60.25 % due to protective biofilm layer and confined envelop around the steel rebar which enhanced structural immunity for corrosion.

eolite clinoptilolite powder nano-micro particles

- Split tensile strength results were improved due to addition of iron oxide as a carrier medium for the Bacillus subtilis and E. coli that was an indication of microstructure confinement in steel concrete bonding zone. 84.2 % improvement in split tensile strength was reported.

- Images of SEM and EDX results confirmed about the calcite deposition in bonding zone and high concentration of bridge like structure was evidence for the biological induced deposit which was further confirmed by XRD and EDTA titrations.

Further it is recommended that genetic modification and biologically trained bacteria can be incorporated in concrete to obtained targeted properties of bio-concrete. Biochemical mimicry can also be implemented to attain good results.



rtex and sonication arrangements

DEVELOPMENT OF LIVE LOAD CALIBRATION FACTOR FOR DESIGNING OF HIGHWAY BRIDGES IN PAKISTAN

Israr Ahmad

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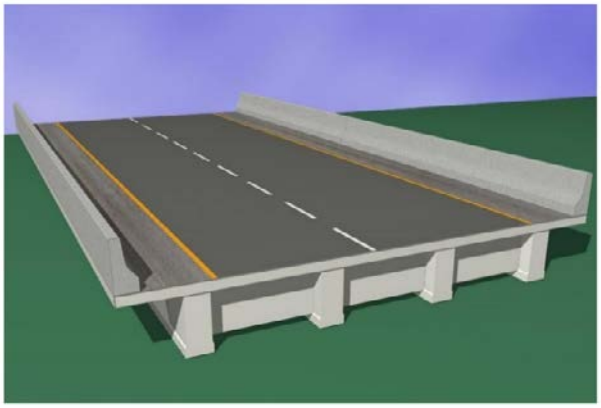
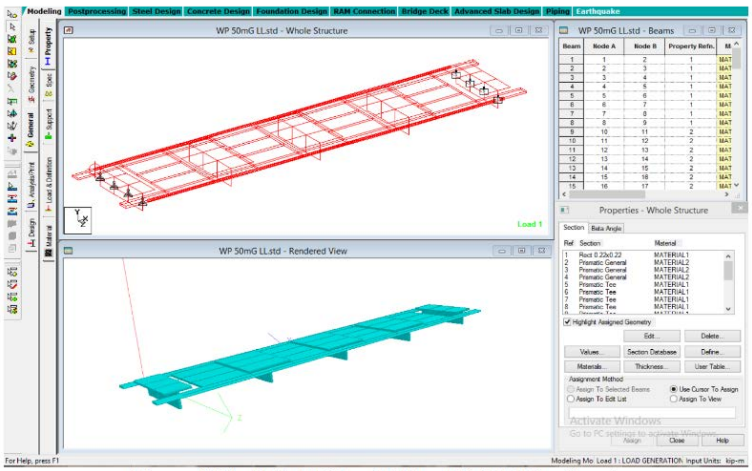


Main Goal:

Bridge structure allows people or vehicles to cross an obstacle such as a river or canal or railway line etc. Among all the impermanent loads on bridge structure, the most frequent one is a vehicular live load. It plays a key role in design of the bridge components and determination of strength of the structure.

Methodology:

Presently, “American Association of State Highway and Transportation Officials (AASHTO)” and “West Pakistan Code of Practice for Highway Bridges – 1967 (WPCPHB-67)” live load models are being followed by designer in Pakistan. Both live load models do not represent the present-day traffic pattern and load in Pakistan. Therefore, the latest traffic data is collected from Sangjani Weigh-in-motion (WIM) station, located at around km 1550 on N-5, the longest and excessively crowded National Highway of Pakistan. Based on statistically analyzed weighing in motion (WIM) traffic data, a comparison is made with live load models of AASHTO, WPCPHB-67 and NHSO-2000 legal load limits to derive Calibration Factors. National Highway Authority’s (NHA) standard two lane simply supported pre-stressed Girder Bridge having varying span length of 20 meters, 30 meters, 40 meters and 50 meters are modeled in STAAD Pro. (Educational Version) Consequently, Live load effects are studied by applying all the above mentioned lodgings to the modeled bridge structures. Based on this study, Calibration Factor “r” obtained as 1.69 and 2.02 for WPCPHB-67 and AASHTO respectively are proposed for designing of NHA standard two-lane bridges in Pakistan.



Conclusion:

This study compared the live load effects present day traffic with the renowned codes like WPCPHB and AASHTO in order to obtain the Calibration Factors. The comparison is also made with the NHSO 2000 legal load limits. The results of this study led to the following conclusions:

- AASHTO and WPCPHB live loading are not true representative of present-day traffic data in Pakistan. Based on the weighing in motion data, the present traffic loading effects are much more than the WPCPHB and AASHTO live loadings.
- NHSO 2000 legal load limits are not implemented properly. Consequently, more than 85% of the vehicles passed from Sangjani weighing station were overloaded.
- Calibration Factor of 1.69 should be used with the WPCPHB live loading models. Its mean that the WPCPHB live loading should be increase by 69% in order to cater for the present-day traffic.
- For AASHTO (HL-93) live loading, Calibration Factor of 2.02 should be used for designing of bridges in Pakistan.
- The results obtained are compared with the previous study. The comparison shows that with the passage of time, the WIM data effects has been increased drastically hence resulting in increase in live load calibration factors.

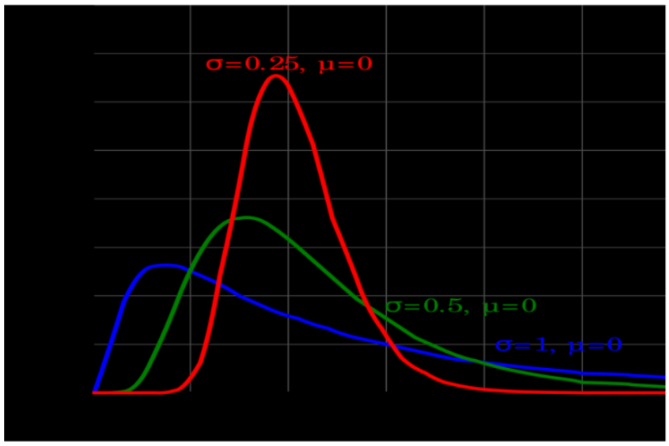
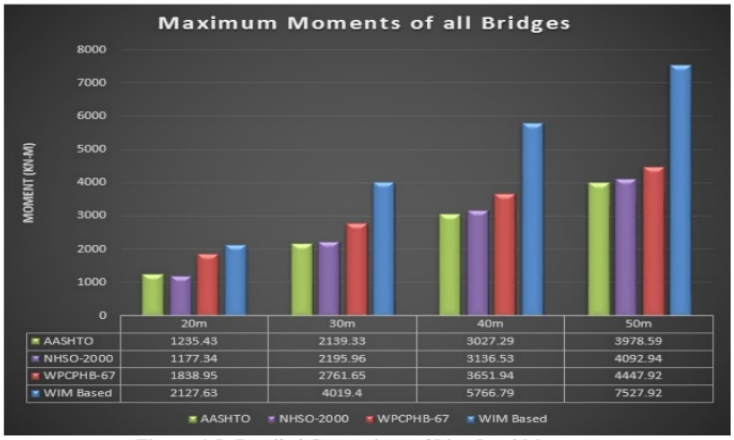


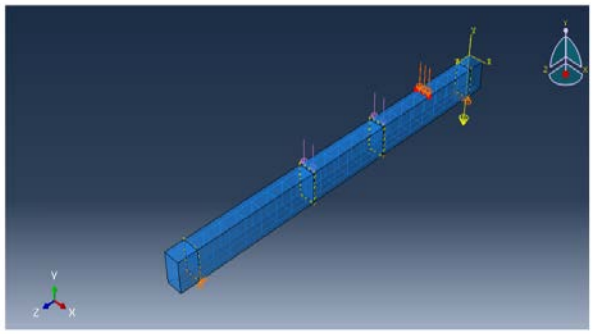
Figure 2.4: Probability Density Function, Lognormal Distribution



	20m	30m	40m	50m
AASHTO	1235.43	2139.33	3027.29	3978.59
NHSO-2000	1177.34	2195.96	3136.53	4092.94
WPCPHB-67	1838.95	2761.65	3651.94	4447.92
WIM Based	2127.63	4019.4	5766.79	7527.92

Figure 4.5: Detailed Comparison of Live Load Moments

Damage Assessment of Reinforced Concrete Beams Using Vibration Characteristic



Abdul Rehman Shafiq Mughal

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Main Goal:

The research has focused on investigating nonlinear behavior of concrete and incorporating in the health monitoring of civil infrastructure, while improving the SHM procedures in terms of inverse engineering problem and sensitivity.

Methodology:

Civil Engineering structures comprise the bridges and buildings, and most of them are constructed using reinforced concrete. However, due to various factors like change in traffic density, environmental effects, and natural hazards, the structures are deteriorating before design life. Reinforced concrete bridges are more prone to these damages because they are constantly exposed to dynamic loads. Currently employed damage assessment techniques include biennial inspections which are also prone to lack of objectivity. The most popular damage assessment method, damage assessment using degradation in natural frequencies, has shown to be not much sensitive to damage and is reported to be influenced by environmental effects.

This research develops a plastic damage model and simulates the nonlinear behavior of concrete using finite element model of concrete. A comparison with the frequency degradation method, which does not show nonlinear behavior is made in terms of sensitivity. The FE model of beam is simulated at different damage levels under various dynamic loads and various analysis have been performed which use linear and nonlinear approach. The comparison of Modal dynamic analysis and Implicit dynamic analysis shows that the implicit dynamic analysis is capable of reproducing the nonlinearities by showing the super harmonics and changes in modal frequencies for harmonic vibrations.

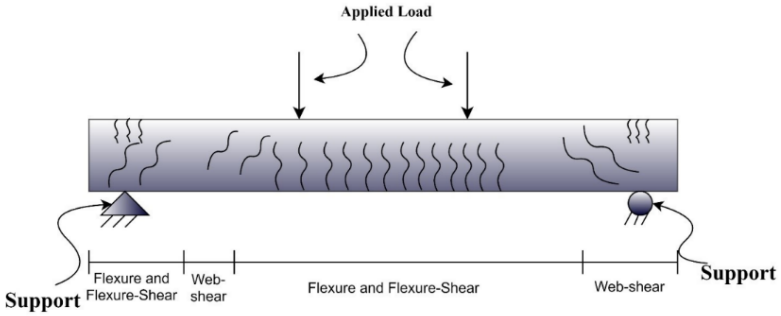
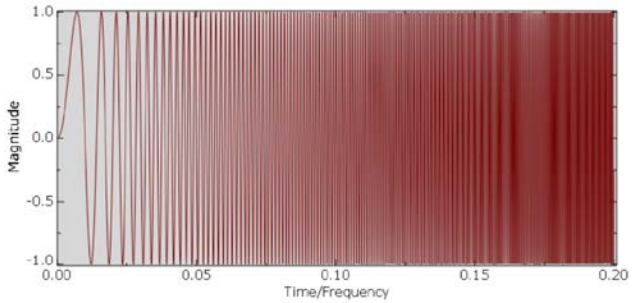


Figure 4.3: Types of cracking in concrete beam (ACI, 2014)



Graph of amplitude against time of swept sine

Conclusion:

A coupled damage and plasticity model was proposed in this study. The constitutive modeling, finite element modeling and the characterization of nonlinear behavior has been used to propose a damage assessment method which addresses the constraints which have not been resolved yet. The model formulation makes it convenient for engineers and researchers to investigate the damage of concrete in more detail and gain more insights incorporating the existing simplified research. Based on the aforesaid explanations, the following conclusions can be drawn.

1. The development of constitutive relations depends only on one strength index (compressive strength of concrete) and capable of simulating the damage in RC concrete.
2. Nonlinear behavior, simulated using Dynamic implicit integration schemes, was sensitive to damage. Following are the response-vise findings:
   - Frequency response of modal dynamic and dynamic implicit show similar behavior indicating the inability of natural frequencies to show nonlinear behavior.
   - From formation of super-harmonics, the nonlinearity coefficient showed most sensitivity at 50% damage.
   - From Restoring force surfaces the model stiffness shows up to 75% reduction in model stiffness at complete damage.
3. Most of RC bridges have pre-stressing effects. The effect of pre-stressing has not been considered and should be incorporated in future research.
4. Even with the availability of computational power the solution Procedures are time consuming, however optimization of the procedure may lead to saving the computational cost.

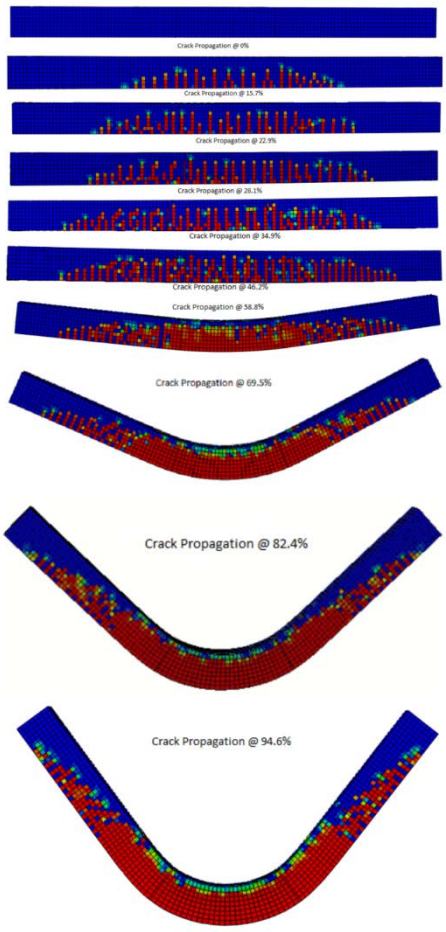


Figure 4.4: Crack propagation of FE model

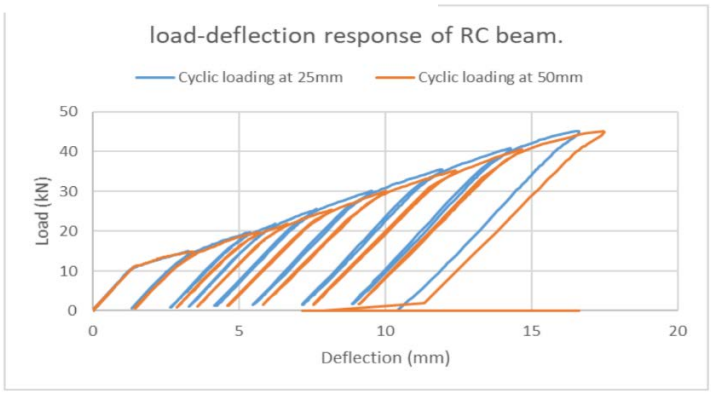


Figure 4.2: load-deflection response of RC beam under cyclic loading

An Efficient Model for Predicting the Shear Strength of RC Knee Joint Subjected to Opening and Closing Moment

Moiz Tariq

Supervisor: Dr. Azam Khan

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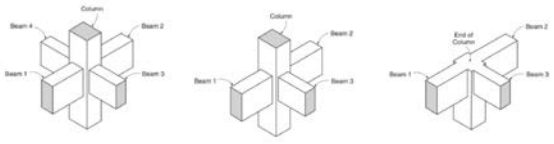

Figure 1.2: Types of RC Joints (a) Interior Joint (b) Exterior Joint (c) Corner Joint

Main Goal:

Reinforced concrete (RC) beam-column knee joints are intrinsically distinct from the traditional RC interior and exterior joints. The RC knee joint has two distinct load resistance mechanisms. Its shows different behavior at the time of reversed cyclic load for closing and opening. Given the many distinct variations in the behavior of shear strength in RC knee joints, the main design codes in the world do not provide any specific design RC knee joint. This is because there is no profound research on the knee joint. An investigation for predicting the shear capacity of reinforced concrete (RC) knee joints under opening and closing moment has been proposed in this research.

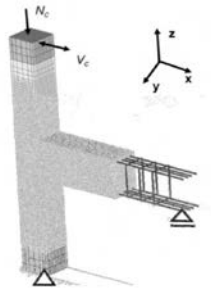

Figure 2.10: FE model of beam-column joint proposed by Genesio

Methodology:

Experimental data in the literature were used to test the exactness and reliability of the proposed model. The proposed model could forecast with good accuracy the experimental response of poorly defined RC knee joints under opening and closing moment. Parametric experiments have been performed to demonstrate the profound influence of different geometric and material properties on the RC knee joints. A method will render the model ideal for practical applications. Average Plane Stress Plane Strain-Based Models. The main objectives of this study are as follows:

- To study the behavior of the knee joint under seismic loading.
- To study the complete force transfer mechanisms of the knee joint when subjected to the cyclic loading.
- To propose an efficient model for estimating the shear strength of the knee joint under reversed cyclic loading.

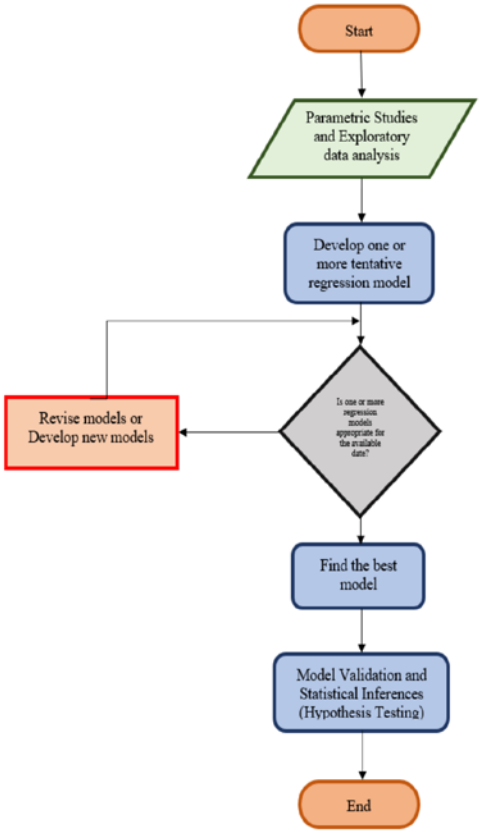

Figure 3.12: Flowchart for developing regression model for RC knee joint

Conclusion:

Shear behavior of the RC knee joint has not been fully understood because of several reasons. The assembly of the RC knee joint is different from that of the interior and exterior joints. The RC knee joint is subjected to reverse cyclic load, has two distinct behaviors, i.e., opening and closing behavior. It is essential to understand better and predict the shear capacity of the RC beam-column knee joint for its broader application in the construction industry. Many researchers have developed analytical and numerical tools for predicting the shear strength of the RC knee joint. Developing such a model is a challenging task as there are several parameters such as concrete compressive strength, joint aspect ratio, steel tensile strength, and quantity of longitudinal and shear reinforcement. This research utilized previous experimental data to develop an equation for predicting the shear strength of the RC knee beam-column joint under the opening and closing behavior using regression analysis.

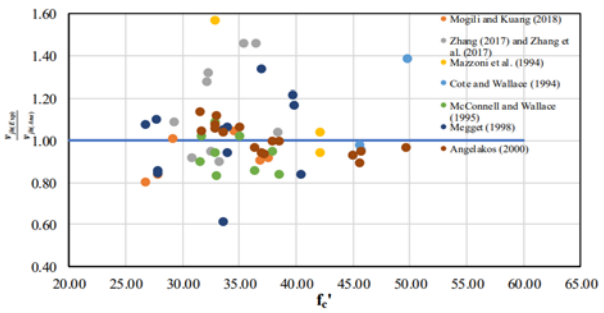

Figure 4.19: Strength ratio variation in RC knee joint under Opening behavior

Several equations were developed to predict the shear strength of the RC knee joint based on concrete compressive strength, joint aspect ratio, and characteristics of longitudinal and shear stirrups, which were found to produce good results. In this study, the equation developed for the RC knee joint using regression could predict the shear strength of the RC knee joint with accuracy than any of the other previous models.

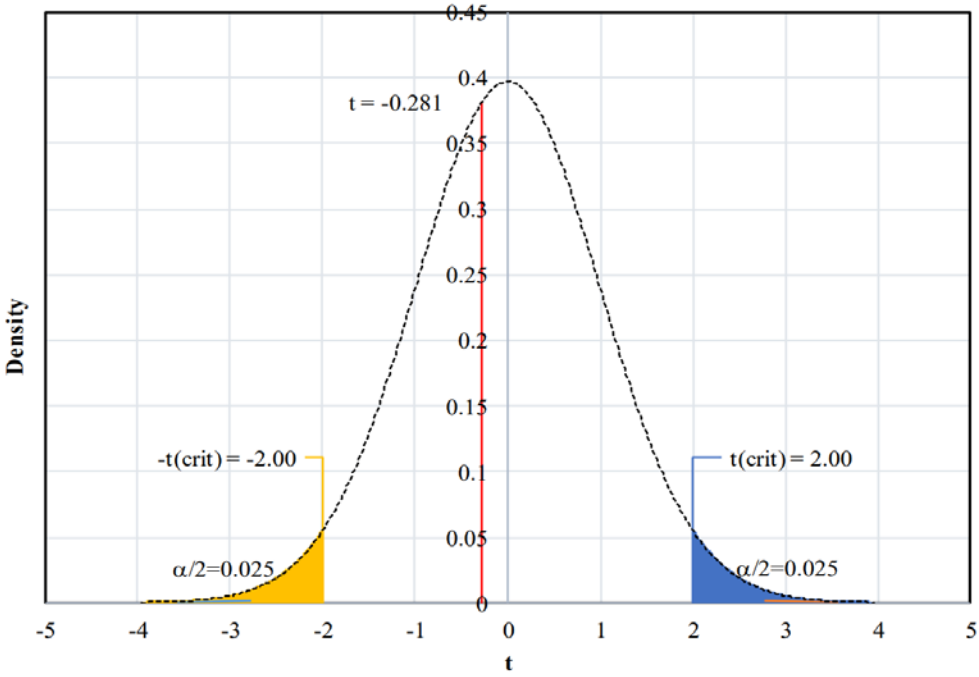

Figure 4.13: Student's t-test for shear strength of the knee joint Under Closing Behavior

Modal Identification and Model Updating of a Turbine Foundation Structure Using Ambient and Forced Vibrations

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Figure 3.13. The installation of accelerometers for the purpose of recording vibration data.

Main Goal:

This study focuses on the estimation of modal properties (natural frequencies, mode shapes and damping ratio) and model updating of a turbine foundation structure, located at Guddu, Pakistan. Sources of excitations are eccentric mass vibrator (EMV) operating at different rpm with constant interval of time and ground waves generated from nearby thermal power plants running as per their routine.

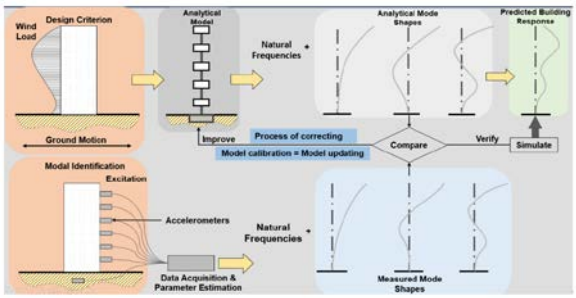

Figure 1.1. Process of modal identification and model updating.

Methodology:

Modal identification was performed using two techniques: first one is “frequency domain decomposition” (FDD), an operational modal analysis (OMA) technique and other “numerical algorithm for subspace state-space system identification” (N4SID), an experimental modal analysis (EMA) technique. Response of the system was measured using high sensitivity microelectromechanical system (MEMS) tri-axial accelerometers. A system order of 2 to 60 was used in the N4SID method to extract the modal properties of the structure. First seven modes were identified using FDD and N4SID techniques. Four are bending dominant while three are torsional dominant. A good match was found between two techniques when compared through modal assurance criteria (MAC).The stabilization diagram was used to separate physical modes of the system from the spurious modes. After modal identification of the foundation structure, model updating was performed using FEMTools to correlate the finite element (FE) model with the experimental model. Now, this tuned FE model after model updating of the system better represents the actual condition of the structure and can be used for rehabilitation and retrofitting techniques.

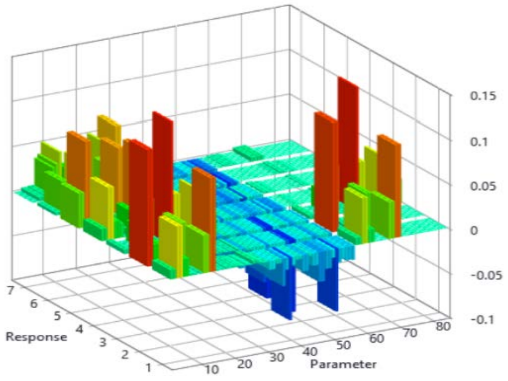

Figure 4.11. Sensitivity matrix of the structure.

Conclusion:

In this research, modal identification and model updating of the turbine foundation structure is performed using ambient and forced vibrations. Based upon the analysis of recorded acceleration data and after analysis, following conclusions can be deduced: -

- A total of seven vibration modes (four bending dominant and three torsional dominant) were identified clearly using the analysis of processed recorded acceleration data. The estimated natural frequencies from two techniques matched well with a difference of −1.5 + % except for second frequency in which difference was more than 8 %.
- The identified damping ratios from the N4SID technique are 0.31 to 14.04 %, which shows variation in damping ratio estimates.
- The Auto-MAC matrix of the identified modes from FDD and N4SID satisfied the orthogonality condition between mode shapes. This is illustrated by a much lower offdiagonal values in the Auto-MAC matrix as compared to the diagonal entries (MAC values equal to 1.0).
- The Cross-MAC between identified modes from FDD and N4SID also showed a good match between modal identification results of the two techniques. The diagonal terms are in the range 0.92 to 0.99 (values taken from MAC matrix), which represent an excellent match between results of two modal identification techniques.
- Percentage difference between frequency after model updating reduced to two percent and MAC between FE model and experimental model has diagonal values greater than 0.8, which represents the accuracy of the model updating procedure

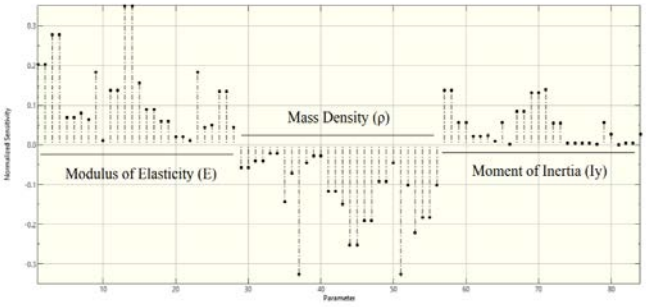

Figure 4.12. Parameters vs normalized sensitivity of the structure.

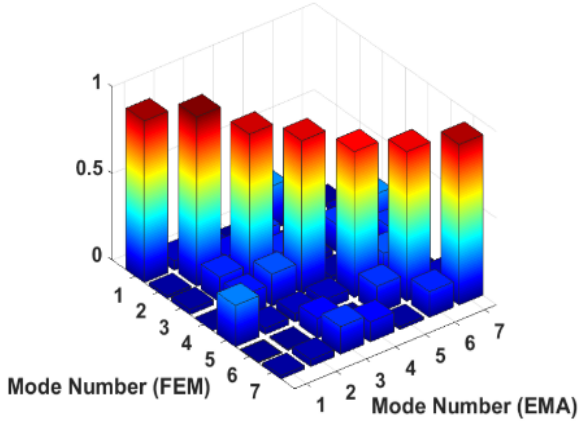

Figure 4.16. MAC between modes of FE model and experimental model after model updating.

DEPARTMENT NEWS

Consultation Projects

Department did several consultation projects for numerous private and public sector clients during the year 2021. The net worth of these projects was more than 8 million PKR. Following projects were carried out

- Expanded Polystyrene Smart (EPS) Panels Testing
- Cracks Depth Measurement and Concrete Properties Assessment using PUNDIT – CF SILO Bestway Cement Kalar Kahar
- Vibrational and Non Destructive Testing of Turbine Foundations – Guddu Barrage
- Assessment of Concrete Quality of Base Slab Foundation at German Embassy Islamabad
- Concrete Core Sampling and Testing of Rehmanabad Mall, Rehmanabad Chowk, Murree Road, Rawalpindi
- Feasibility Study and Detailed Engineering Design of: Repair and Rehabilitation of DI KHAN Bridge at D.I Khan

Who joined and who left

- Dr. Junaid Ahmad, PhD from University of Wollongong, Australia joined the department. He has research expertise in the experimental testing of RC columns with FRP.
- Lec. Sara Farooq left the department to pursue her PhD from Japan. We wish her best of luck.

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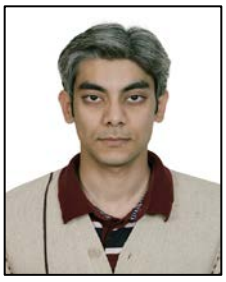

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