EARTHQUAKE RESISTANCE BUILDINGS AND CONSTRUCTION PRACTICES

A DISSERTATION
Submitted in Partial Fulfilment of the Requirements
for the degree
of

MASTERS OF ARCHITECTURE

BY
Ar. ESRAR AHAMAD
Enrolment number-12101090049

Under the supervision of
Ar. ANSUL SINGH
(Asst. Professor)

SCHOOL OF ARCHITECTURE AND PLANNING
BBD University, Lucknow

BBD UNIVERSITY

TO THE
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BABU BANARSI DAS UNIVERSITY, LUCKNOW

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ANNEXURE II

CERTIFICATE

It is certified that the work contained in this thesis entitled

"EARTHQUAKE RESISTANCE BUILDINGS AND CONSTRUCTION PRACTICES"

by **Esrar ahamad** (Roll No 1210109001), for the award of **"Master of Architecture"** from "Babu Banarasi Das University" has been carried out under my/our supervision and that this work has not been submitted elsewhere for a degree.

Ar Esrar Ahamad

(M. Arch final year)

Ar. Ansul Singh

(Asst. Professor)

School of Architecture and planning

BBD university, lucknlow-226016

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Date: - June 2024

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Annexure IV
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CERTIFICATE OF THESIS SUBMISSION FOR EVALUATION

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1. Name : **Esrar Ahamad**
2. Enrolment No.: 12101090049
3. Thesis title: **Earthquake Resistance Buildings and Construction Practices.** YES ☐ NO ☐
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6. Thesis Preparation Guide was referred to for preparing the thesis. YES ☐ NO ☐
7. Specifications regarding thesis format have been closely followed. YES ☐ NO ☐
8. The contents of the thesis have been organized based on the guidelines YES ☐ NO ☐
9. The thesis has been prepared without resorting to plagiarism. YES ☐ NO ☐
10. All sources used have been cited appropriately.
11. The thesis has not been submitted elsewhere for a degree.
12. Submitted 2 spiral bound copies plus one CD.

Name: Ar. **Esrar Ahamad**
Enrolment No. 12101090049

LIST OF CONTENT

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Ar. Esrar ahamad

M. Arch. final Year

(Session: 2023-2024)
School of Architecture and planning.
BBD university, Lucknlow-226016

ABSTRACT

Earthquakes are among the most devasting natural disasters, as they can cause significant destruction to infrastructure as well as the loss of human life. Due to the increasing urbanisation and population density in seismically active regions, there is an immediate and critical need for the development of efficient construction techniques that are earthquake resistant. In this study, earthquake- resistant construction techniques are investigated, and a variety of aspects, including materials, design principles, and construction methods, are dissected and examined. It is anticipated that the study, which is being carried out by professionals in the fields of civil engineering and earthquake engineering, will contribute to the development of better earthquake-resistant construction techniques that can improve the safety of structures in areas that are prone to seismic activity.

Researchers are investigating potential future developments in the field of earthquake-resistant design of structures as the importance of this topic continues to grow. The advancements in technology and design methodologies that are the focus of this paper are those that have the potential to improve the safety and resilience of structures in the face of seismic activity. The study investigates the utilisation of cutting-edge materials, cutting-edge design methodologies, and cutting-edge building practises. The author places a strong emphasis on the importance of ongoing research and development in this field and makes a plea for collaboration between engineers, architects, and construction professionals to ensure that the most recent technological advancements are incorporated into the design and construction of buildings.

The use of neural network inversion is currently being investigated by researchers as a potential method for further enhancing the design of earthquake-resistant buildings. Utilizing the information obtained from seismic sensors, this method seeks to improve the earthquake resistance of building designs. This study investigates the application of neural network inversion to the problem of optimally designing buildings to withstand earthquakes. The authors provide evidence that this method is effective and highlight its potential for enhancing the safety and resiliency of buildings in seismically active regions.

Recent developments in methods of earthquake-resistant construction are also being investigated at this time. In this paper, the most recent advancements in construction methods, materials, and design methodologies are discussed. These advancements have the potential to improve the safety and resilience of buildings in the event of an earthquake. The authors stress the significance of incorporating these technological advancements into the design and construction of buildings to ensure the structural integrity of buildings located in seismically active regions.

To summarise, earthquakes continue to represent a significant risk to the structural integrity of buildings and infrastructure all over the world. As a consequence of this, there is an increasing demand for efficient construction methods that are earthquake resistant. The importance of ongoing research and development in this field is brought to light by this study, which investigates several different aspects of techniques for earthquake-resistant construction. In addition to this, the paper investigates potential developments that may occur in the design of structures that are resistant to earthquakes, the application of neural network inversion to the optimisation of building design, and recent advancements in earthquake-resistant building practises. As professionals in the fields of civil engineering, earthquake engineering, and construction work towards enhancing the safety and resiliency of structures in seismically active regions, the findings of these studies are likely to be of significant interest to those professionals.

KEY WORDS:

Earthquake, Resistant Design, RC Buildings, Seismic Response, Soft Storey, High Rise Building, Structural Steel Analysis, Commercial Factories, Loading, Shear Wall, Multi-Story Building, Nayagaun Settlement, Kavre, Gorkha Earthquake, Infrastructure, Seismic Design, Northern Pakistan, Case Study, Recent Innovation, Optimal Design, Neural Network Inversion, Recent Advances, Construction Practices, Future Trends, Earthquake-Resistant Design, Structures, Construction Techniques.

CHAPTER – I : INTRODUCTION:

INTRODUCTION:

One of the most devastating natural disasters is an earthquake, which destroys vast amounts of infrastructure and kills many people. The development of efficient earthquake-resistant construction methods has become essential due to the growing urbanization and population density in seismically prone areas. In order to design and build structures that can withstand seismic forces and reduce the risk of damage or collapse during an earthquake, it is essential to study earthquake-resistant construction techniques.

This study aims to investigate and evaluate various earthquake-resistant building techniques that have been created and used around the world. Experts in the fields of civil engineering and earthquake engineering are involved in conducting the study.

The study focuses on the various elements of earthquake-resistant construction methods, such as the materials used, the design ideas, and the construction techniques. The study examines the suitability of these methods for various kinds of structures as well as their efficacy in reducing earthquake damage.

The study is anticipated to help advance earthquake-resistant building practices that will increase the security of structures in seismically active regions. The results of this study can be helpful for civil engineers, architects, and construction specialists who are involved in designing and building infrastructure and buildings in seismically vulnerable areas.

To ensure the safety and resilience of structures in the face of seismic activity, the study on earthquake-resistant construction techniques is extremely important. It is hoped that the knowledge gleaned from this research will aid in the creation of stronger, more efficient building methods that are better able to withstand the forces of nature.

Buildings must be designed to be earthquake-resistant in order to lessen the effects of Earthquakes on buildings and the people who live and work inside of them.
This awareness has grown over the past few years.

Future developments in the design of structures that are earthquake-resistant are a crucial area for research and development in the discipline of earthquake engineering. New and better design methodologies, materials, and construction techniques have been created as a result of technological advancements and increased understanding of the behavior of earthquakes. The safety and resilience of structures in the face of seismic activity are anticipated to be significantly impacted by these trends.

This paper, written by renowned earthquake engineering expert Durgesh C. Rai from the Department of Earthquake Engineering at the University of Roorkee in India, focuses on the analysis of future trends in earthquake-resistant design of structures. The article is a part of a special section on seismology in 2000 where experts talk about the most recent developments and trends in the discipline of earthquake engineering.

The use of cutting-edge materials, modern construction methods, and creative design methodologies are just a few of the topics covered in this essay's exploration of various facets of earthquake-resistant building design. The author discusses the potential applications of these trends in various types of structures as well as how effective they are at lessening the effects of earthquakes on infrastructure and buildings.

The paper concludes that in order to ensure the safety and resilience of structures in the face of seismic activity, future trends in earthquake-resistant design of structures are essential. In order to ensure that the most recent developments are incorporated into building design and construction, the author emphasises the need for ongoing research and development in this field and calls for collaboration between engineers, architects, and construction professionals.

In conclusion, the paper emphasises the significance of designing structures to be earthquake-resistant and the part future trends will play in ensuring the safety and resilience of structures and infrastructure in the face of seismic activity.
Professionals in the fields of earthquake engineering, civil engineering, and construction are anticipated to be particularly interested in the findings of this paper.

1.2 NEED OF THE PROJECT :

Earthquake-resistant construction requires that the building be properly grounded and connected through its foundation to the earth.

Building on loose sands or clays is to be avoided, since those surfaces can cause excessive movement and nonuniform stresses to develop during an earthquake.

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1.3 Grand Challenges in Earthquake Engineering Research.

Grand challenges in earthquake research are the problems, barriers, and bottlenecks in the earthquake engineering field that hinder realization of the NEHRP vision—“A nation that is earthquake resilient in public safety, economic strength, and national security” (NEHRP, 2008). As such, they define frontiers in basic earthquake engineering research that would be needed to provide transformative solutions for achieving an earthquake-resilient society. Thirteen grand challenge problems emerged over the course of the workshop. The committee has summarized them in terms of five overarching Grand Challenges, described below, in order to capture interrelationships and crossovers among the 13 problems and to highlight the interdisciplinary nature of their potential solutions. Participants noted that grand challenge problems do not stand alone; they are complex, and this complexity exists not only within earthquake engineering but also in earthquake engineering’s position among other competing social challenges. As such, addressing a grand challenge problem involves consideration of a variety of barriers—economic, regulatory, policy, societal, and professional—along with the scientific and technological solutions. The five overarching Grand Challenges are intended to serve as useful focal points for discussions among stakeholders and decision makers planning future investment toward achieving a more earthquake-resilient nation.

CHAPTER –I : AIM , OBJECTIVE AND SCOPE:

2.1 AIM OF THE PROJECT:

The main Aim of the study is comparative analysis with the latest construction techniques and trends of Earthquake-resistant construction.

THE PROBLEM

Most of the loss of life in past earthquakes has occurred due to the collapse of buildings, constructed in traditional materials like stone, brick, adobe and wood, which were not particularly engineered to be earthquake resistant. In view of the continued use of such buildings in most countries of the world, it is essential to introduce earthquake resistance features in their construction.

1.1 SOCIO-ECONOMIC CONSIDERATIONS IN SEISMIC SAFETY OF BUILDINGS

From the results of studies on the performance of buildings during past earthquakes, it appears that

(i) Certain building types should entirely be ruled out in seismic zones having probable seismic intensity of VIII or more on Modified Mercalli or the MSK Intensity Scales. This would include earthen houses, random rubble masonry as well as brickwork in clay mud mortar, and the like;

(ii) (ii) rich mortars involving cement and lime should be used in fired brick and coursed stone masonry; and

(iii) Substantial steel reinforcement should be introduced in the walls in both directions of the building.

1.3 OBJECT AND SCOPE

The object of this book is to deal with the basic concepts involved in achieving appropriate earthquake resistance of such buildings as stated above, which may be collectively called as Non-Engineered Buildings; to include suitable illustrations to explain the important points, and to present such data which could be used to proportion the critical strengthening elements. The term non-engineered building may only be vaguely defined as buildings which are spontaneously and informally constructed in the traditional manner without intervention by qualified architects and engineers in their design but may follow a set of recommendations derived from observed behaviour of such buildings during past earthquakes and trained engineering judgement. Specifically such buildings will include load bearing masonry wall buildings, stud-wall and brick-nogged constructions in wood, and composite constructions using combinations of load bearing walls and piers in masonry, reinforced concrete, steel or wood, and the like. Reinforced masonry, reinforced concrete or steel frame buildings, tall buildings using various types of structural systems, and major industrial buildings, etc., are excluded from consideration although some of the principles stated herein will apply to these constructions with equal force.

Methodology

The importance of shear walls in multi-story buildings for earthquake resistance is covered in the essay "A Review on Effect of the Positioning of Shear Wall for Earthquake Resistance Multi-Story Building." The authors review the impact of shear wall positioning on a building's seismic response. The paper discusses various shear wall types, their placement in buildings, and how they affect seismic behaviour. The authors come to the conclusion that a multi-story building's seismic performance is significantly influenced by the location of the shear wall.

The paper offers a thorough review of the literature on the subject of multi-story building shear wall positioning. The collection and analysis of the relevant research done by the authors is excellent. The paper, however, lacks original research and offers no fresh perspectives on the subject. The paper is more of a literature review than a research paper because the authors only summarise the previously published research.

Overall, the study offers insightful information on the significance of shear walls for earthquake resistance in multi-story buildings. To further validate the findings, the paper would be more beneficial if it included original research, such as case studies or experiments.Before the Gorkha Earthquake, an earthquake-resistant assessment of building construction methods was conducted in the Nayagaun Settlement of Kavre. The seismic performance of buildings in Nayagaun Settlement of Kavre, Nepal, prior to the Gorkha earthquake is the main topic of the paper "Earthquake Resistant Assessment of Building Construction Technique in the Nayagaun Settlement of Kavre before Gorkha Earthquake." The authors evaluated the seismic resistance of the local buildings after conducting a survey of them. In addition to highlighting the buildings' weak points in seismic resistance, the paper offers insights into the construction methods used in the region.

The analysis of the seismic performance of the buildings in Kavre's Nayagaun Settlement prior to the Gorkha earthquake in the paper is excellent. The survey and evaluation conducted by the authors reveal important details about the region's building construction methods as well as their shortcomings. In addition, the paper makes recommendations for retrofitting and bettering building codes to enhance the seismic performance of nearby buildings.

The research does, however, have some shortcomings. The authors' analysis is restricted to the Nayagaun Settlement of Kavre, and it's possible that the conclusions cannot be applied to other regions. It is also difficult to assess the efficacy of the suggested solutions because the paper offers no data on the seismic performance of buildings in the region following the Gorkha earthquake.

In general, the study offers useful details about the seismic performance of buildings in Kavre's Nayagaun Settlement prior to the Gorkha earthquake. The findings can be applied to enhance seismic design and construction methods in the region, and the paper's limitations are minimal in comparison to its contributions.

The significance of seismic design and building codes in the construction of earthquake-resistant buildings and infrastructure is covered in the paper "Construction of Earthquake Resistant Buildings and Infrastructure Implementing Seismic Design and Building Code in Northern Pakistan 2005 Earthquake Affected Area." The paper focuses on the difficulties encountered when building earthquake-resistant structures in the Northern Pakistan region affected by the 2005 earthquake.

The paper offers an excellent analysis of the difficulties encountered when building earthquake-resistant structures in the region of Northern Pakistan that was affected by the 2005 earthquake. The authors discuss the significance of seismic design and building codes in creating buildings that can withstand earthquakes and highlight the difficulties in putting these codes into practise in the region.

CHAPTER –III: CASE STUDY:

3.1 CASE STUDY: *(2015 Nepal earthquake)*

Kathmandu	
Date	**25 April 2015**
Origin time	**11:56:26 NST**
Magnitude	**7.8 M_w[1] or 8.1 M_s**
Depth	**8.2 km (5.1 mi)**
Epicenter	**28.147°N 84.708°ECoordinates: 28.147°N 84.708°E**
Type	**Thrust**
Areas affected	• **Nepal** • **India** • **China** • **Bangladesh**
Total damage	**≈$5 billion (about 25% ofGDP)**
Max. intensity	**IX (*Violent*)[1]**
Aftershocks	**7.3 M_w on 12 May at 12:50**

	6.7 M_w on 26 April at 12:54 **417 aftershocks of 4 M_w and above as of 25 Nov 2015**
Casualties	**8,857 dead in Nepal (officially) and 8,964 in total 21,952 injured (officially)**

<u>Nepal earthquake...</u>

The April 2015 Nepal earthquake (also known as the Gorkha earthquake) killed over 8,000 people and injured more than 21,000. It occurred at 11:56 Nepal Standard Time on 25 April, with a magnitude of 7.8 or 8.1$M_s$and a maximum Mercalli Intensity of IX (*Violent*). Its epicenter was east of the district of Lamjung, and its hypocenter was at a depth of approximately 8.2 km (5.1 mi). It was the worst natural disaster to strike Nepal since the 1934 Nepal–Bihar earthquake.

The earthquake triggered an avalanche on Mount Everest, killing at least 19, making April 25, 2015 the deadliest day on the mountain in history. The earthquake triggered another huge avalanche in the Langtang valley, where 250 people were reported missing.

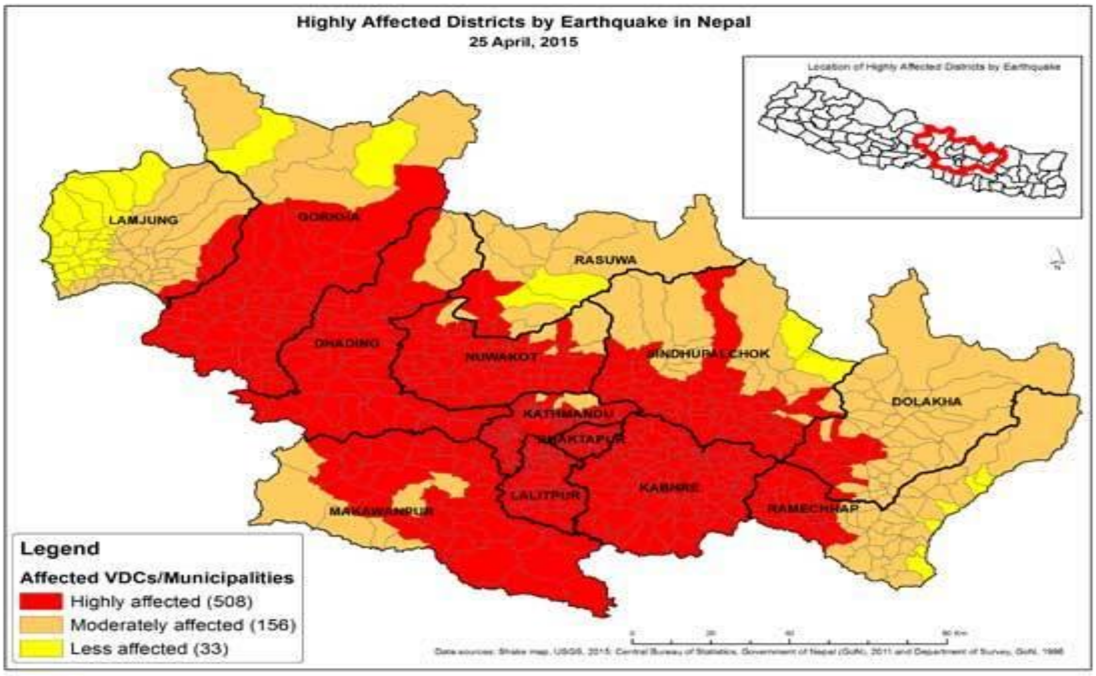
Hundreds of thousands of people were made homeless with entire villages flattened, across many districts of the country. Centuries-old buildings were destroyed at UNESCO World Heritage sites in the Kathmandu Valley, including some at the Kathmandu Durbar Square, the Patan Durbar Square, the Bhaktapur Durbar Square, the Changu Narayan Temple and the SwayambhunathStupa. Geophysicists and other experts had warned for decades that Nepal was vulnerable to a deadly earthquake, particularly because of its geology, urbanization, and architecture.

Continued aftershocks occurred throughout Nepal at the intervals of 15–20 minutes, with one shock reaching a magnitude of 6.7 on 26 April at 12:54:08 NST. The country also had a continued risk of landslides.

A major aftershock occurred on 12 May 2015 at 12:50 NST with a moment magnitude (M_w) of 7.3. The epicenter was near the Chinese border between the capital of Kathmandu and Mt.

Everest. More than 200 people were killed and more than 2,500 were injured by this aftershock.

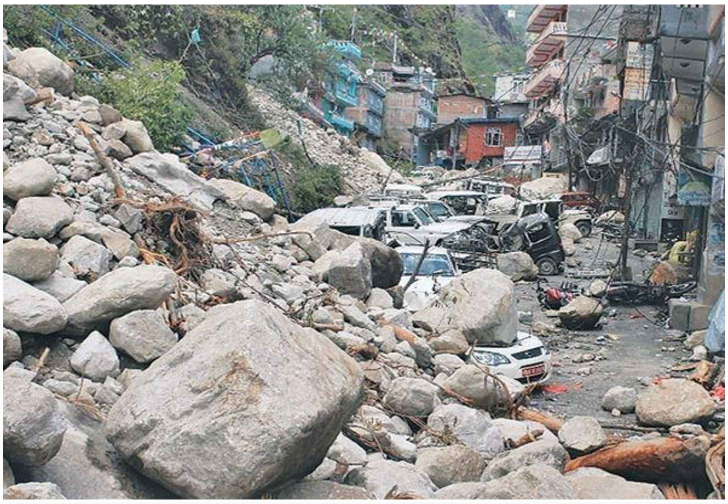
Nepal's Everest sinking 7.9 Earthquake of April 25-2015: Himalayan warning



The massive Nepal earthquake of 7.9 intensity (Richter scale) on April 25, 2015 with epicenter 77 km north-west of Kathmandu in Nepal is a major noteworthy event in the Himalayas which also has warnings for what is in store for future. The earthquake left a major trail of destruction affecting over 20 districts of Nepal, of which 8 million live in 11 severely affected districts. Besides, it affected areas of India (Bihar, UP, W Bengal, Sikkim, Assam), Bangladesh, Tibet. The earthquake has now been given the official name of Gorkha Earthquake.

The intensity of this earthquake is generally comparable with the 2005 earthquake in Kashmir which killed over 86,000 in Pakistan and India. This is the largest earthquake in Nepal since the Bihar-Nepal earthquake of 1934. The 1934 earthquake was 8.3 magnitude and centered near Mount Everest, more than 10,000 people were killed.

India Meteorology Department[1], provides a list of 85 aftershocks till May 4, 2015 after the earthquake of April 25, 2015. The list is given in Annexure 1.



Arniko Highway landslide Photo from E Kantipur

❖ <u>Impacts in Nepal</u>

- According to Nepal Government, 7557 people have died, 14536 are injured, 10718 government buildings are totally destroyed and 14741 government buildings are partially affected. 191058 private buildings are destroyed and 175162 are damaged. Total affected population is 2 649 4504. The figures continue to rise.
- *Kathmandu valley a meter up at the cost of Mount Everest!* According to scientists from the European Space Agency, post earthquake, the Kathmandu Valley area of about 120 km by 50 km has risen by up to a meter. A 24 hour GPS survey confirmed that indeed the valley altitude is up 80 cm from 1338 m to 1338.8 m after the earthquake (*Kathmandu is now 80cm taller* The Times of India, May 7, 2015). The Mount Everest has sunk by one inch and areas north have settled below their original height probably because the land below loosened up, as built up strain was released. That possibly triggered the base camp avalanche that killed 22 people.
- *The Hindu* reported that the Kathmandu valley is more vulnerable to damage as underneath the valley is a 300 m deep layer of black clay, the remnants of a prehistoric lake, which amplifies the damage caused by severe earthquakes.
- The damage was worse in the region in the regions of the quake, in the Gorkha-Lamjung region, the Burhi Gandaki valley and Ganesh Himal. Kathmandu was badly hit because it is built on old lake sediments that are highly susceptible to shaking. As the Himalayas rise, the rivers will cut back by headwall erosion. Some large rivers like Arun (a tributary of Kosi) have cut a long way north beyond the main Himalayan axis. But course of the rivers take longer to change and is not immediately visible. The active thrust fault dips about 5-10 degrees to the north of the Himalayan front. The earthquake depth, about 15 km below the Gorkha region was on this rupture. The maximum amount of slip along the fault that ruptured may have been 4-5 m but the fault did not break to the surface.

A peculiarity of this Nepal Earthquake is that almost all the aftershocks and most of the damage has been caused in areas to the EAST of the epicenter of the earthquake, very little to the west. I have been wondering how can this be explained and asking a number of persons, but have yet to find a satisfactory reply. As noted by David Petley in his blog on April 26, 2015, "In the case of the Nepal Earthquake the rupture appears to have propagated mostly towards the east of the epicentre, not to the west. So the epicentre itself is at the west end of the earthquake affected zone. This is clear from the USGS shakemap."

Noteworthy positives The earthquake response has thrown up some positives too. The effort of the common people in the immediate impact zone has been praiseworthy at many places. The prompt response of Indian government, including air-force, NDRF and others has been acknowledged by the Nepal government. Indian state governments have also been providing useful help to the affected people and others. Indian and international media have been trying their best to give a true picture of the situation.

THE QUAKE EXPOSED MANY FAILURES In the aftermath of the earthquake, a number of failures of India's response system were exposed.

- Dysfunctional NDMA The National Disaster Management Authority has been dysfunctional for many months, since all the members (except one) of the NDMA resigned in June 2014 after Modi government took over. It was only in January 2015 that three of the eight new members were appointed. In the meantime, the annual drill of the disaster management this year was cancelled. This does not sound great for India's premier disaster management institute. A former member of the NDMA and senior official of NDRF confirmed this situation to this author.
- Quake Monitoring Network in Coma: *The Hindustan Times* reported, "The country's network of "ground-motion" detectors, the backbone of quake monitoring, has not been working for nearly eight months now due to a bureaucratic bottleneck, putting millions of lives at risk." Ground or strong-motion detectors — also called accelerographs — are critical as they serve as the basis for India's earthquake early-warning system, but they were found to be lying idle in the aftermath of the Nepal India's network of 300 strong-motion sensors, installed at critical points across 14 states, cover high-risk seismic zones V and IV as well as some heavily populated cities in zone III. These imported devices, which measure movement generated during a quake and also help identify areas that could be vulnerable, cost Rs 10 crore to install and about Rs 1 crore a year to maintain. In Sept 2014, the government moved the project out of IIT-Roorkee after it decided to carve out a separate seismological organisation from the India meteorological department. Funding was cut off in September 2014, without an alternative arrangement in place. When this author asked very senior official of government of India about this, he confirmed that yes, there has been problem in transition to Geological Society of India, but hoped that the instruments were recording the readings and that the readings in any case will be useful at a latter date.

- India has fewer GPS stations than Nepal *The Indian Express* reported that Nepal has a network of 300-400 GPS instruments spread over the entire fault line, while India does not have more than 25-30 that are permanently deployed. These instruments help monitor the tectonic movements. A top earthquake expert, Roger Bilham of Colorado University (US) said that Nepal in fact is better prepared than India to withstand strong earthquakes since it has started taking remedial measures several years back.
- Lack of actionable landslide maps during disaster While our government and various agencies talk about this prowess of Remote Sensing images providing information, what was required in the immediate aftermath of the earthquake was quick information from this source about the possible sites where earthquake had led to landslides so that rescue and relief action can be taken up. This was particularly important when communication and transport was completely disrupted in the remote areas. However, we did not see any useful actionable inputs in this regard from India's (or for that matter from other countries) remote sensing agencies.
- No Post Disaster reporting One of the key way to learn lessons for future from disasters is to have comprehensive reporting about what happened at the disaster and who played what role. Unfortunately we have no such comprehensive report about even the Uttarakhand disaster of June 2013 that killed between 6500 and 30 000 people as per different estimates. NDRF director General and a former member of NDMA who were with me at a Lok Sabha TV discussion after the April 25 earthquake agreed we need such reports

It is good to see that Union Ministry of Earth Sciences have decided to put in place a topological model for India to understand earthquakes better . The government is also going to set up 10 seismic stations each in Nepal and Myanmar. Dr Shailesh Nayak, Secretary, Union Ministry of Earth Sciences hopes that this will help understand physics of earthquake, first step in move towards predicting earthquakes. There are over 66 active faults in India, the Himalayan belt is dissected by 15 major active faults. India currently has 84 seismic stations, and has placed orders to increase this number to 130.

DAMAGED HYDROPOWER PROJECTS Experts have been warning about the danger of building large dams in the seismically unstable Himalayas, where the collapse of large infrastructure can magnify devastation in mountains. Such role of the projects in Uttarakhand flood disaster in June 2013 was confirmed by the Expert Body (chaired by Dr Ravi Chopra) appointed by the Union Ministry of Environment and Forests (MoEF) following the Supreme Court order of Aug 2013 and also as per the affidavit of the MoEF in the Supreme Court in December 2014.

Deaths, damages at Rasuwagadi HEP The huge earthquake caused serious damage to the 111 MW Rasuwagadhi Hydropower station, which a Chinese company started to build two years ago, 67 kilometers west of the quake's epicenter in Rasuwa district of Central Development

Region. The China Three Gorges Company & media reported that two Chinese & four Nepalese workers were killed in the quake and several were seriously injured. On April 28, a child and 24 other people were airlifted by helicopter to nearby Jilung County in China's Tibet Autonomous Region, according to the quake relief headquarters in Jilung. The dam itself has suffered serious damages. The Rasuwagadhi Dam was being built on the upper Trishuli River in a very remote corner of Nepal near the Tibetan border. The dam's reservoir is to stretch back 25 km, holding back 1500 million cubic metres of water (these figures are The Ecologist article by Michael Buckley, if anyone has contrary figures, pl let us know with reference). Writer Michael Buckley asks in his article in *The Ecologist*: "Rasuwagadhi Dam was described as severely damaged by the quake. And that brings up a nightmare scenario. What if that dam were up and running, with a huge reservoir sitting behind it? … It would be a Fukushima moment – earthquake followed by tsunami."

Workers stuck at Upper Tamakoshi HEP In a news report that appeared eight days after the earthquake, Ganesh Neupane, chief of the environment division of the Upper Tamakoshi Hydropower Company Limited[13], said some 200 Chinese technicians and engineers as well as 70 Nepalese workers are stranded in the powerhouse station at the hydropower project site after a massive landslide caused by the earthquake blocked the 11-kilometer-long Lamabagar-Gongar stretch of the road connecting the region. The 456 MW Project of Nepal Electricity Authority is located at Lamabagar VDC, Dolakha District, Janakpur Zone, Central Development Region. The workers are stuck but safe at the Upper Tamakoshi hydropower project in Lamabagar Area in Dolakha district, where reports suggest that more than 90 per cent of houses in rural areas have been destroyed. The stranded workers are from China's Sinohydro Corporation Limited, the contractor of civil construction work for the Upper Tamakoshi Hydropower Company Limited in charge of the project.

Upper Tamakoshi HEP under construction, it was damaged in the earthquake

Economic loss...

Road damage in Nepal

Nepal, with a total Gross Domestic Product of USD$19.921 billion (according to a 2012 estimate), is one of Asia's poorest countries, and has little ability to fund a major reconstruction effort on its own. Even before the quake, the Asian Development Bankestimated that it would need to spend about four times more than it currently does annually on infrastructure through to 2020 to attract investment.The U.S. Geological Survey initially estimated economic losses from the tremor at 9 percent to 50 percent of gross domestic product, with a best guess of 35 percent. "It’s too hard for now to tell the extent of the damage and the effect on Nepal’s GDP", according to Hun Kim, an Asian Development Bank (ADB) official. The ADB said on the 28th that it would provide a USD$3 million grant to Nepal for immediate relief efforts, and up to USD$200 million for the first phase of rehabilitation.

Social effects...

It was reported that the survivors were preyed upon by human traffickers involved in the supply of girls and women to the brothels of South Asia. These traffickers took advantage of the chaos that resulted from the aftermath of the earthquake.The most affected were women from poor communities who lost their homes.

Minorities/Racial element...

Single women face daunting challenges in obtaining resources after the quake.

Single women have had very little access to relief, according to a report by the Inter-party Women's Alliance (IPWA). The report also found that violence and rapes against women and minors has increased after the earthquake. Additionally, the earthquake has significantly affected certain minorities. Tibeto-Burman (Oriental) races were hardest hit as they tend to inhabit the higher slopes of mountains as opposed to the central valleys, are less educated and connected, and are considered lower caste within Nepali society. All of these factors make them harder to access. According to a government survey, malnutrition in children has worsened considerably some 3 months after the quake, with the most undernourished being Tamang and Chepang peoples. Before the quake, 41 percent of children under five were stunted, 29 percent were underweight and 11 percent were emaciated, according to the World Food Programme.

As of 1 May international aid agencies like Médecins Sans Frontières (Doctors Without Borders) and the Red Cross were able to start medically evacuating the critically wounded by helicopter from outlying areas, initially cut-off from the capital city, Kathmandu,and treating others in mobile and makeshift facilities.There was concern about epidemics due to the shortage of clean water, the makeshift nature of living conditions and the lack of toilets.

3.2 LITRATURE STUDY

• Dhajji-Diwari Buildings of Kashmir

The Dhajji-Diwari buildings were the one of survive when part of the palace and other massive old buildings collapsed in the Srinagar quake of 1885. The most significant aspect of the Dhajji-Diwari buildings is the combination of the building materials used. These materials are locally available and have been used for generations. The basic elements in these buildings are the load bearing masonry piers and infill walls.

There are wooden tie-bands at each floor level. The foundation consists of rubble masonry with lime mortar whereas, mud mortar is used for the rest of the structure.

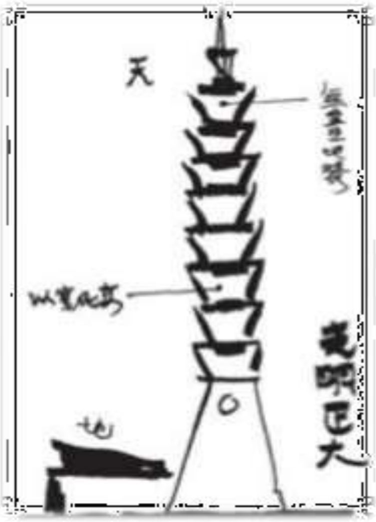
The infill materials are usually abode bricks bonded with mud mortar. The wooden bands tie the walls of the structure with the floors and also impart ductility to a structure that is otherwise brittle. The unreinforced masonry walls have stiffness but not strength. In the absence of strength, flexibility is essential for quake resistance. Here, the desired flexibility is provided by the combination of wood and unreinforced masonry laid in a wear mortar. The wooden beams tie the whole house together and ensure that the entire building sway together as one unit in an earthquake

• Kat-Ki- Kunni Buildings of Kulu Valley

Similar to the Pherols and the Dhajji-Diwari buildings, the Kat-KiKunni or timber cornered buildings suffered minimal damage in the epicentral tract of Kulu Valley during the 1905 Kangra earthquake. This structure is almost identical to the Pherols of Uttarkashi. It combines the weight, solidity an coolness of a stone building with the flexibility and earthquake-resisting qualities of a wooden one.

TAIPEI 101

- ARCHITECT – C.Y.LEE & PARTNERS
- ADDRESS – TAIPEI CITY ,TAIWAN.
- CONST. MATERIAL – STEEL,IN SITU CONCRETE AND GLASS
- YEAR STARTED – JUNE 1998 (MALL ALREADY OPEN)
- DATE COMPLETED – DEC 2004
- TOTAL HEIGHT – 508M
- NO. OF FLOORS – 101
- PLAN AREA – 50M X 50M
- COST – $ 700 MILLION
- BUILDING USE – OFFICE COMPLEX + MALL



➢ ARCHITECTURALSTYLE

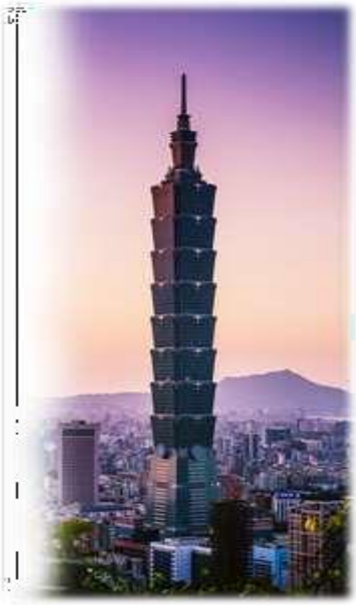
- STRUCTURE DEPICTS A BAMBOO STALK YOUTH AND LONGEVITY
- EVERLASTING STRENGTH

➢ PAGODA STYLE

- EIGHT PROMINENT SECTIONS
- CHINESE LUCKY NUMBER “8”
  - IN CHINA, 8 IS A HOMONYM FOR PROSPERITY
  - EVEN NUMBER = “RHYTHM AND SYMMETRY”

- **STRUCTURAL FACADE:** Taipei 101’s characteristic blue- green glass curtain walls are double paned and glazed, offer heat and protection sufficient to block external heat by 50 percent, and can sustain impacts of 7 tonnes.
- The facade system of glass and aluminium panels installed into an inclined moment-resisting lattices contributes to overall lateral rigidity by tying back to the mega-columns with one-story high trusses and at every eighth floor. This facade system is therefore able to withstandup to 95mm of seismic lateraldisplacements without

BUILDING FRAME:



➢ Materials

- 60 ksi Steel
- 10,000 psi Concrete

➢ Systems

- Outrigger Trusses
- Moment Frames
- Belt Trusses

➢ Lateral Load Resistance

- Braced Moment Frames in the building’s core
- Outrigger from core to perimeter
- Perimeter Moment Frames
- Shear walls

CHAPTER – IV: CONCLUSION

♣ CONCLUSIONS ♣

There is a lack of awareness in the earthquake disaster mitigations. Avoiding non-engineered structures with unskilled labour even in unimportant temporary constructions can help a great way.

♣ State-wide awareness programmes have to be conducted by fully exploiting the advancement in the information technology.

♣ Urgent steps are required to be taken to make the coral provisions regarding earthquake resistant construction undebatable.

In conclusion, this building project has provided us with a valuable learning experience in earthquake resistant design and ductile detailing of concrete structures. As Nepal is located in a seismically active region, it is crucial to consider the safety of structures and human lives during earthquakes. By following the earthquake resistant design code (IS 1983 (Part-I):2016) and ductile detailing of concrete (IS 13920:2016), we have designed a building that is better equipped to withstand lateral earthquake loads and minimize damage. Our team worked together to idealize, analyze, and design the building under the guidance of our respected supervisor, and we hope that our design meets their expectations. We believe that this project has given us a deeper understanding of the transfer mechanism of lateral earthquake loads into vertical members and, finally, into the foundation. Overall, we are grateful for the opportunity to work on this project, and we are confident that the knowledge and skills we have gained will serve us well in our future careers as civil engineers

CHAPTER –V: REFERENCES

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CHAPTER-VI

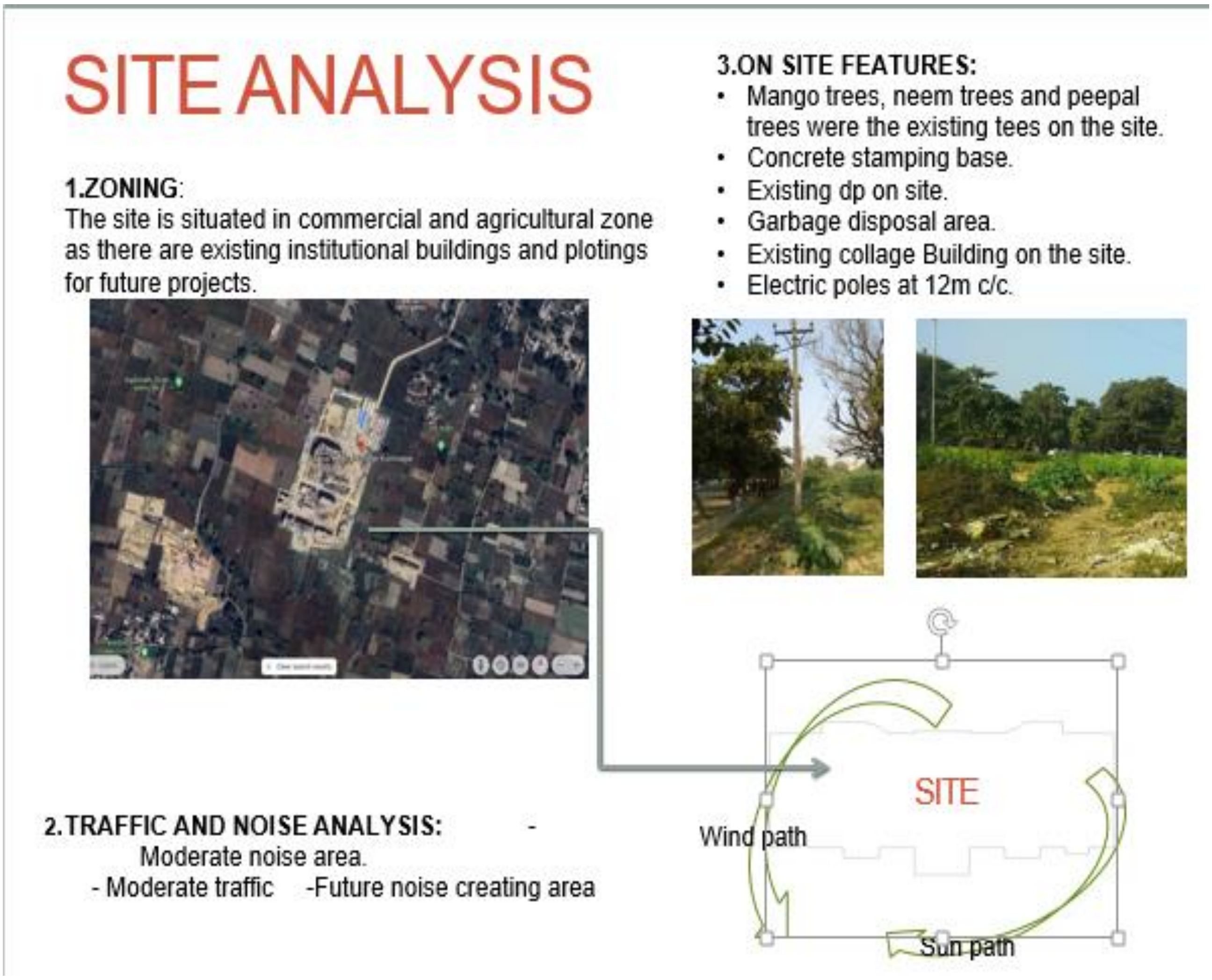
DESIGN

6.1 NEED OF THE PROJECT:

Earthquake-resistant construction, the fabrication of a building or structure that is able to withstand the sudden ground shaking that is characteristic of earthquakes, thereby minimizing structural damage and human deaths and injuries.

6.2 SITE ANALYSIS:

SITE MAP AND LIOCATION:



4.CLIMATE OF KUSHINAGAR

The climate here is mild, and generally warm and temperate. In winter, there is much less rainfall in Kushinagar than in summer. This climate is considered to be Cwa according to the Köppen-Geiger climate classification. The temperature here averages 25.0 °C | 77.0 °F. In a year, the rainfall is 1293 mm | 50.9 inch.

The location Kushinagar is in the northern hemisphere. Summer begins at the end of June and ends in September. The months of summer are: June, July, August, September. The most opportune time to visit are March, October, November.

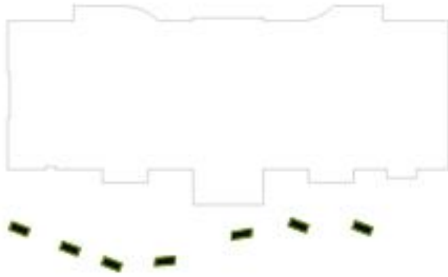
DATA AND GRAPHS FOR WEATHER & CLIMATE IN KUSHINAGAR

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C (°F)	[illegible] (60) °F	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (71) °F	[illegible]
Min. Temperature °C (°F)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Max. Temperature °C (°F)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Precipitation / Rainfall mm (in)	15 (0)	24 (0)	15 (0)	15 (0)	[illegible] (1)	[illegible]	[illegible]	[illegible]	217 [illegible]	47 (1)	3 (0)	8 (0)
Humidity(%)	70%	60%	42%	34%	[illegible]	[illegible]	[illegible]	84%	84%	74%	62%	[illegible]
Rainy days (d)	1	2	2	3	6	[illegible]	[illegible]	[illegible]	[illegible]	4	0	1
avg. Sun hours (hours)	7.9	[illegible]	[illegible]	11.2	[illegible]	[illegible]	7.8	7.3	[illegible]	[illegible]	[illegible]	[illegible]

5.UTILITIES AND SERVICES:

- drainage.
- atm of bank App. 1.5kms
- bus stop. App 2.5 kms
- police station. App. 3 kms

Site has sight slope in north west.



6.COMMUTIVE FACILITY:

- By bus :Nearest bus stand is 4kms away.
- By train :Mohali air port is 3kms away.
-  By air :Kushinagar airport 18kms away.

PROPOSED SITE

*** SITE LOCATION :**

GOVERNMENT MEDICAL COLLAGE AT KUSHINAGAR U.P.

*** SITE AREA :**

26084 SQ.M.

*** SITE NEIGHBOURHOOD :**

- **GOVERNMENT MEDICAL COLLAGE.**
- **GOVERNMENT SCHOOL.**
- **KRISHA BHAWAN.**

*** TOPOGRAPHY AND AMENITIES:**

Site topography is mostly Leveled and average level is .5 to 1 m.

Storm water drains , metaled roads , Sewer line , Street light are available at all around the site.

6.3 CLIMATE ANALYSIS:

Kushinagar has an extreme tropical climate with very cold and dry winters from December to Mid February and dry, hot summers from April to Mid June. The rainy season is from mid-June to mid-September, when it gets an average rainfall of 1000 mm mostly from the south-west monsoon winds. During extreme winter the maximum temperature is around 25 degrees Celsius and the minimum is 3 to 4 degrees Celsius range. Fog is quite common from late December to late January. Summers can be quite hot with temperatures rising to the 40 to 45 degree Celsius range.

The average wind speed in Site location (Kushinagar) is 2.6 m/s with the maximum wind speed of around 10 m/s.

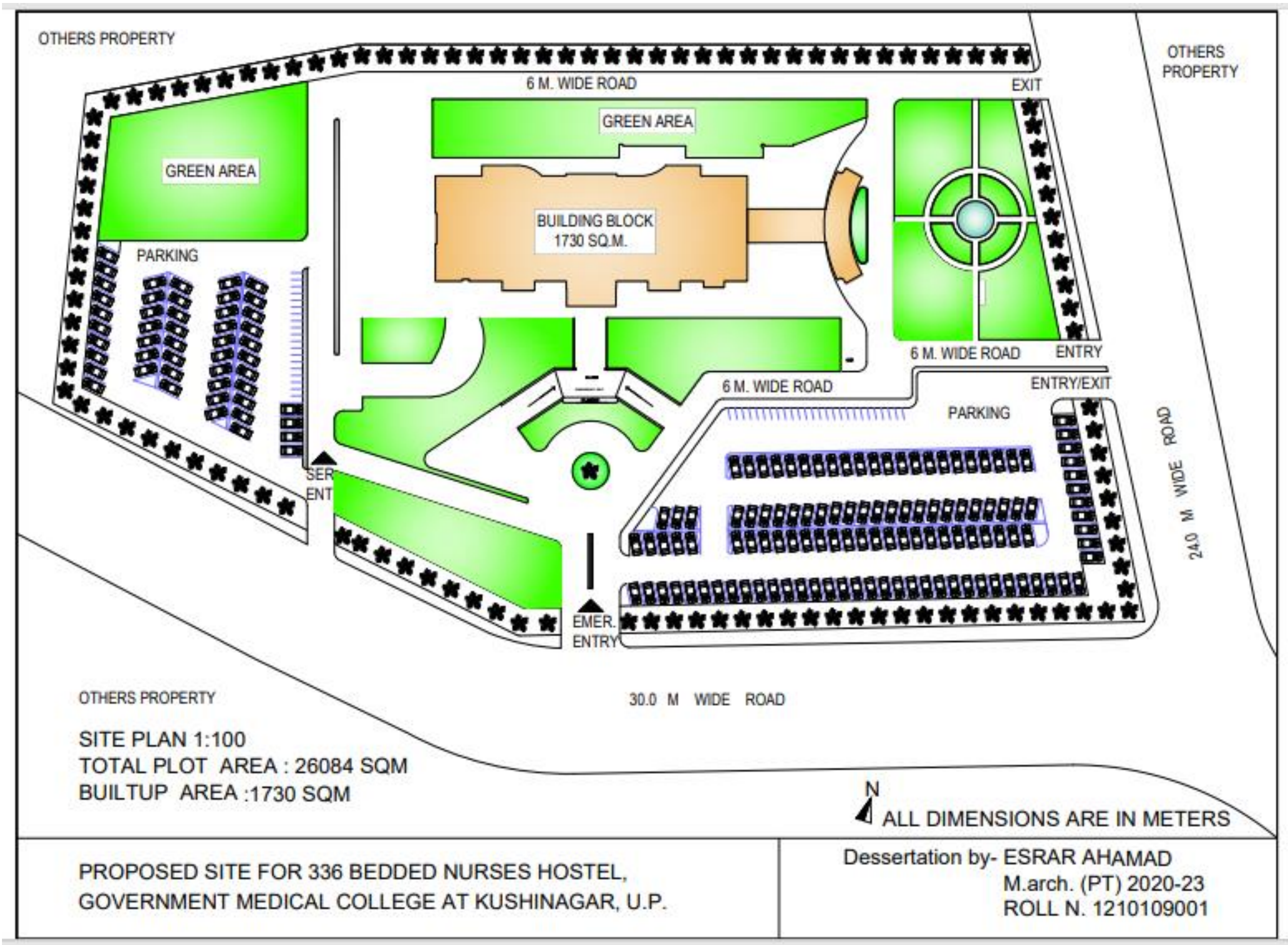
- The average ambient temperature remains 25.3°C, varies from 6.2°C to 41.9°C.
- The average relative humidity remains around 68.6%, varies from 17.5% to 99.7%.

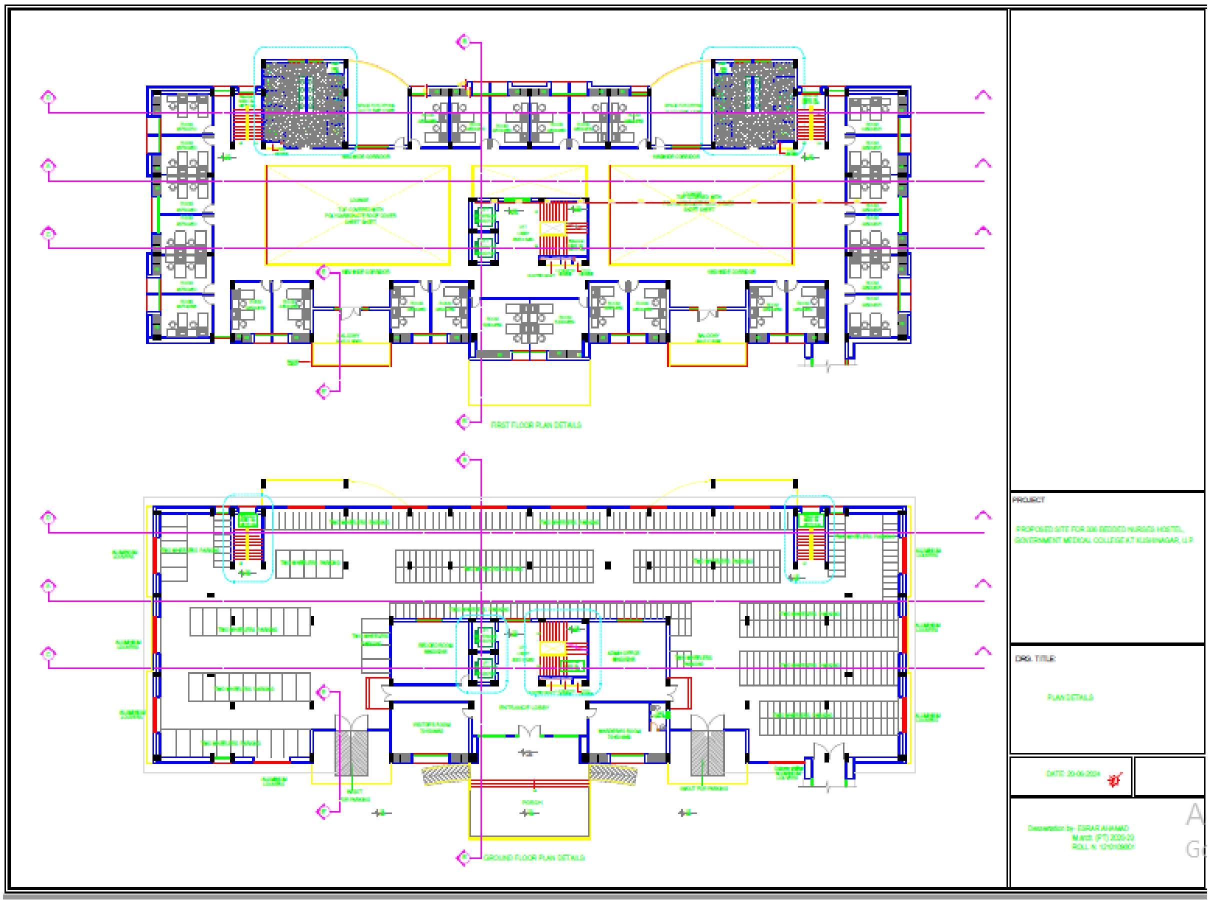
- The station pressure varies from 995 hPa to 976 hPa, averaged around 1011 hPa.
- Windrose of Lucknow shows that predominantly wind blow from the WNW - about 24.75% of all wind directions.

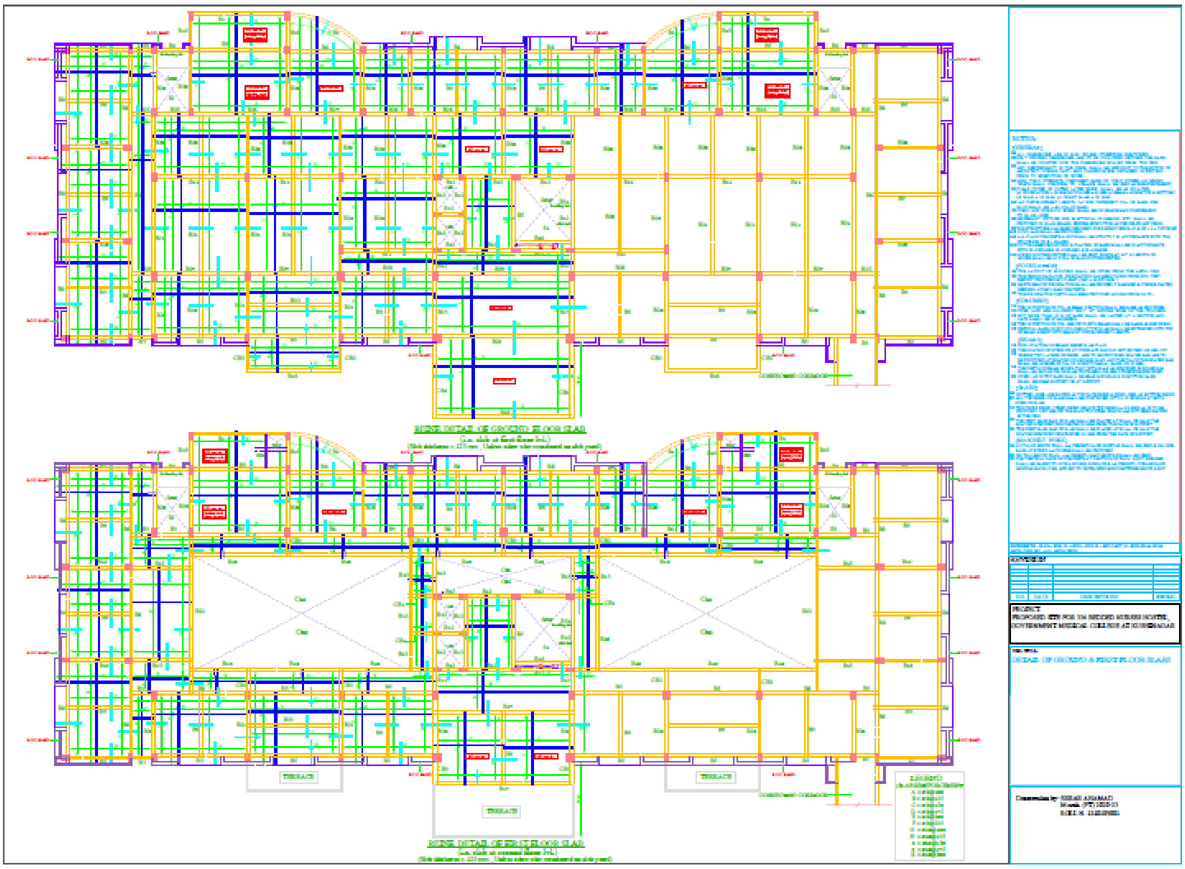
SUN-PATH ANALYSIS:

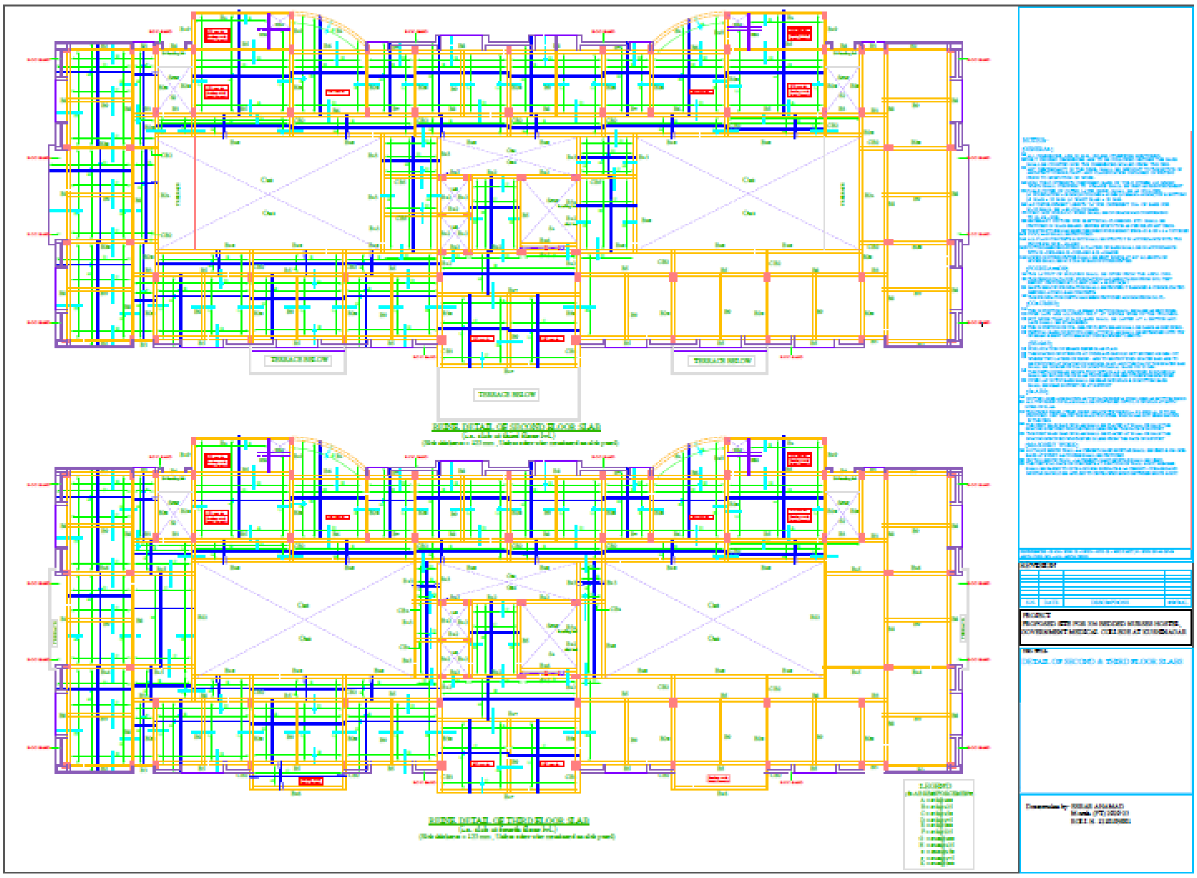
Shadow analysis is a crucial aspect of architectural and urban design, involving the study of how shadows cast by buildings, structures, or natural elements change over time. This analysis provides valuable insights into various aspects of design, urban planning, and environmental considerations. Here are some key aspects and significance of shadow analysis:

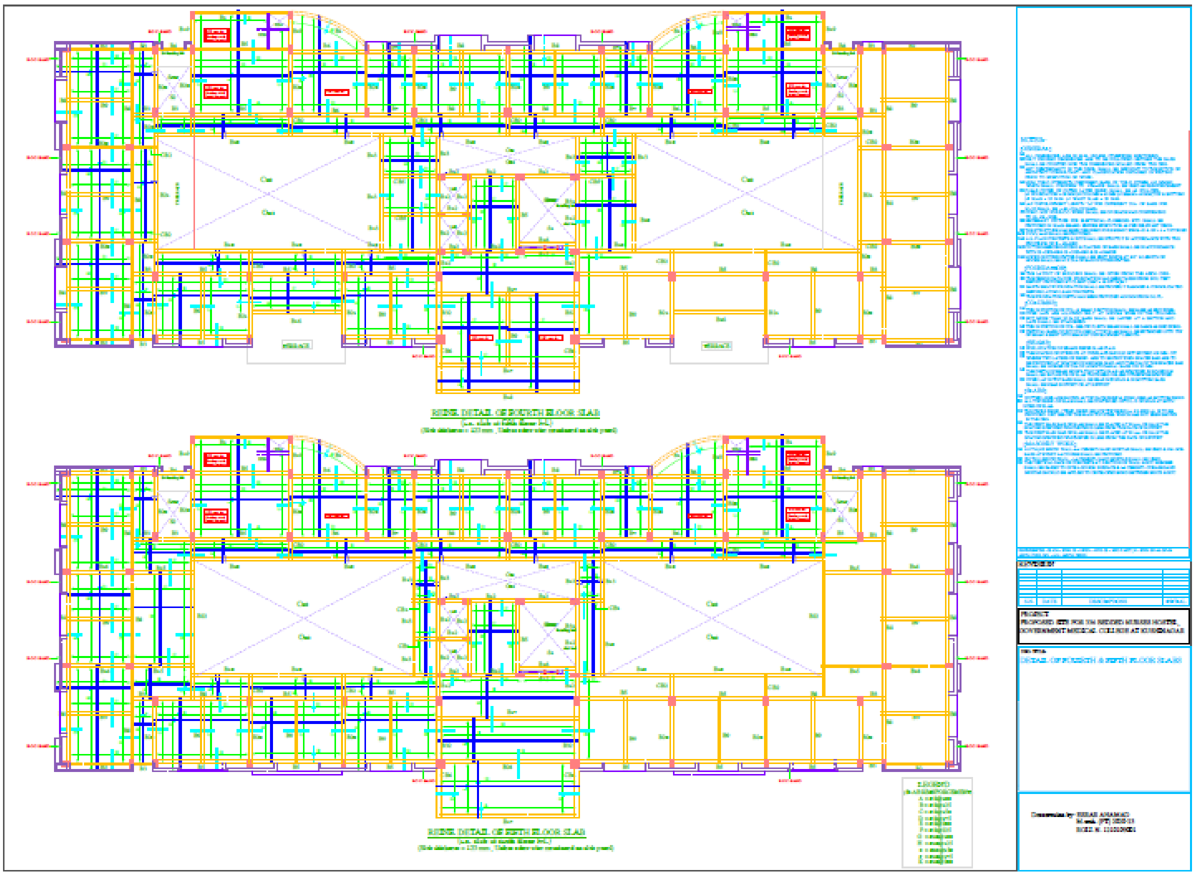
1. **Daylight and Sunlight Studies:**
2. **Energy Efficiency:**
3. **Urban Planning:**
4. **Building Orientation:**
5. **Seasonal Variations:**

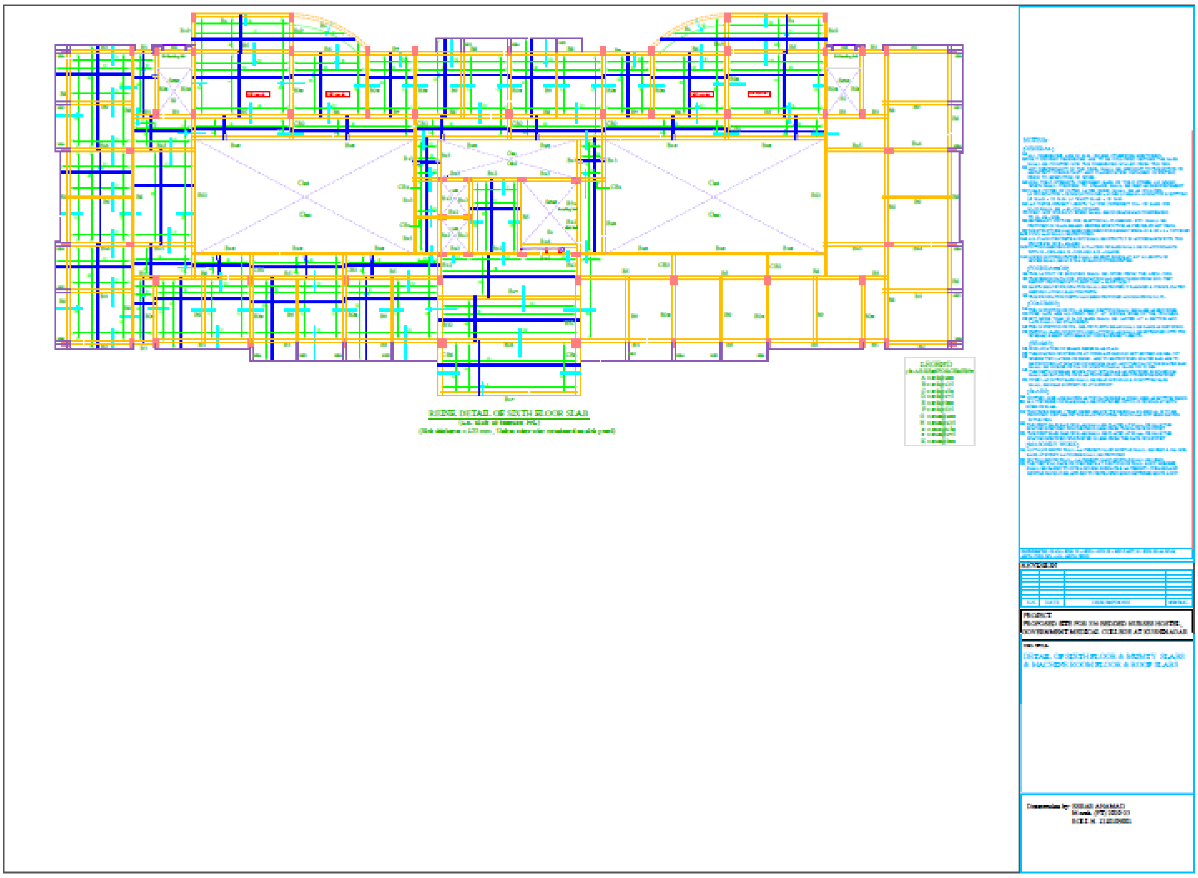


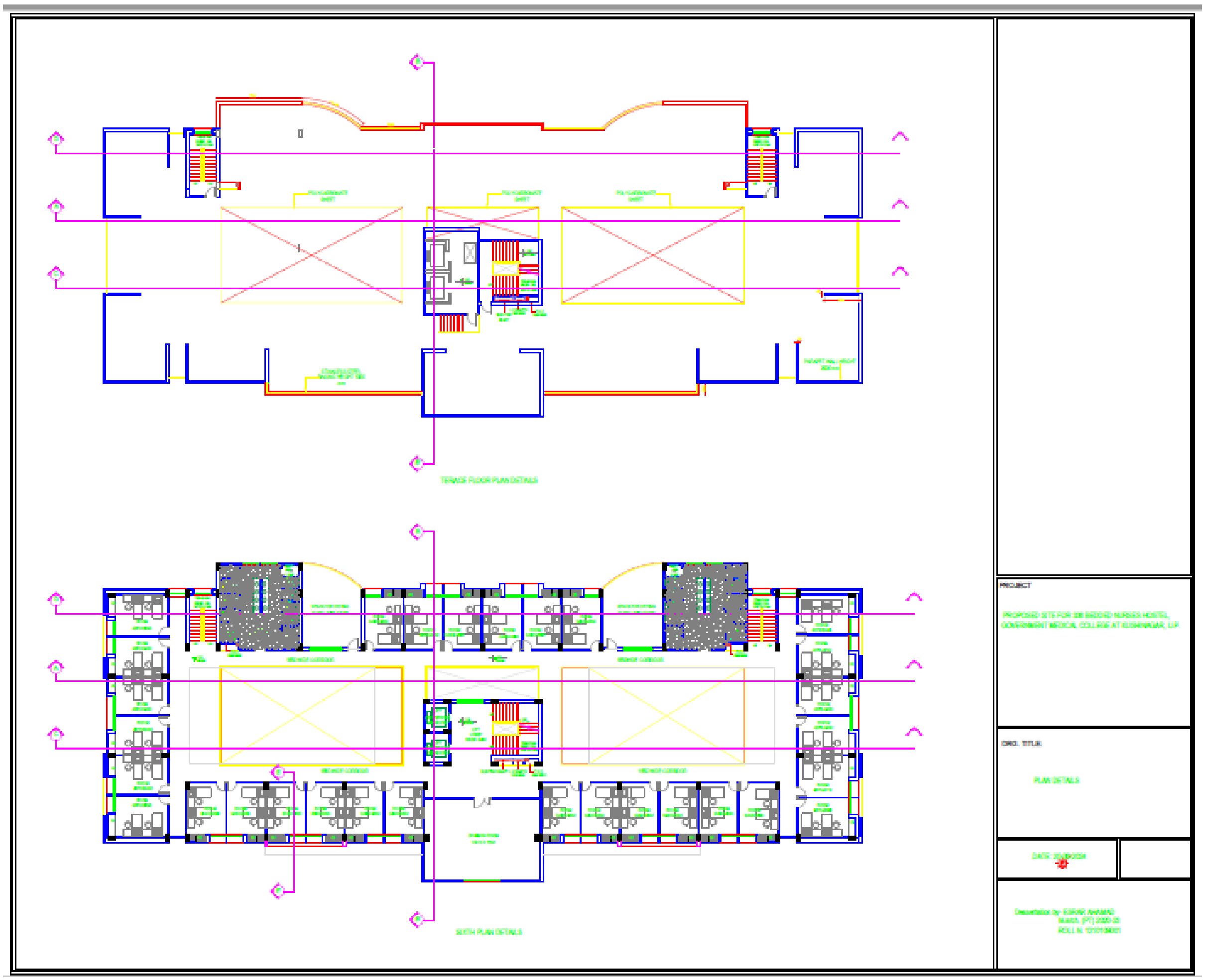

FIRST FLOOR PLAN DETAILS
GROUND FLOOR PLAN DETAILS
PROJECT
GOVERNMENT MEDICAL COLLEGE AT KUSHINAGAR, U.P.
DRG. TITLE:
PLAN DETAILS

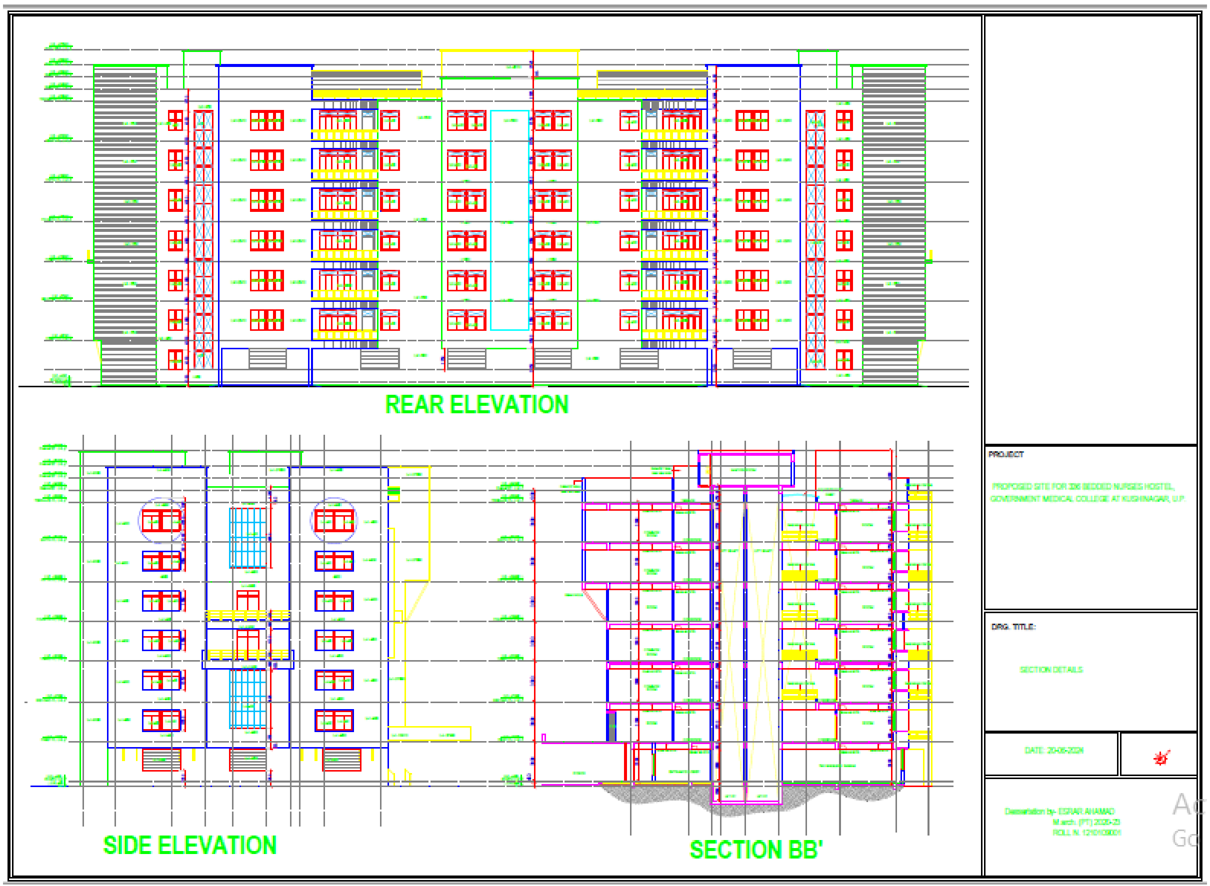


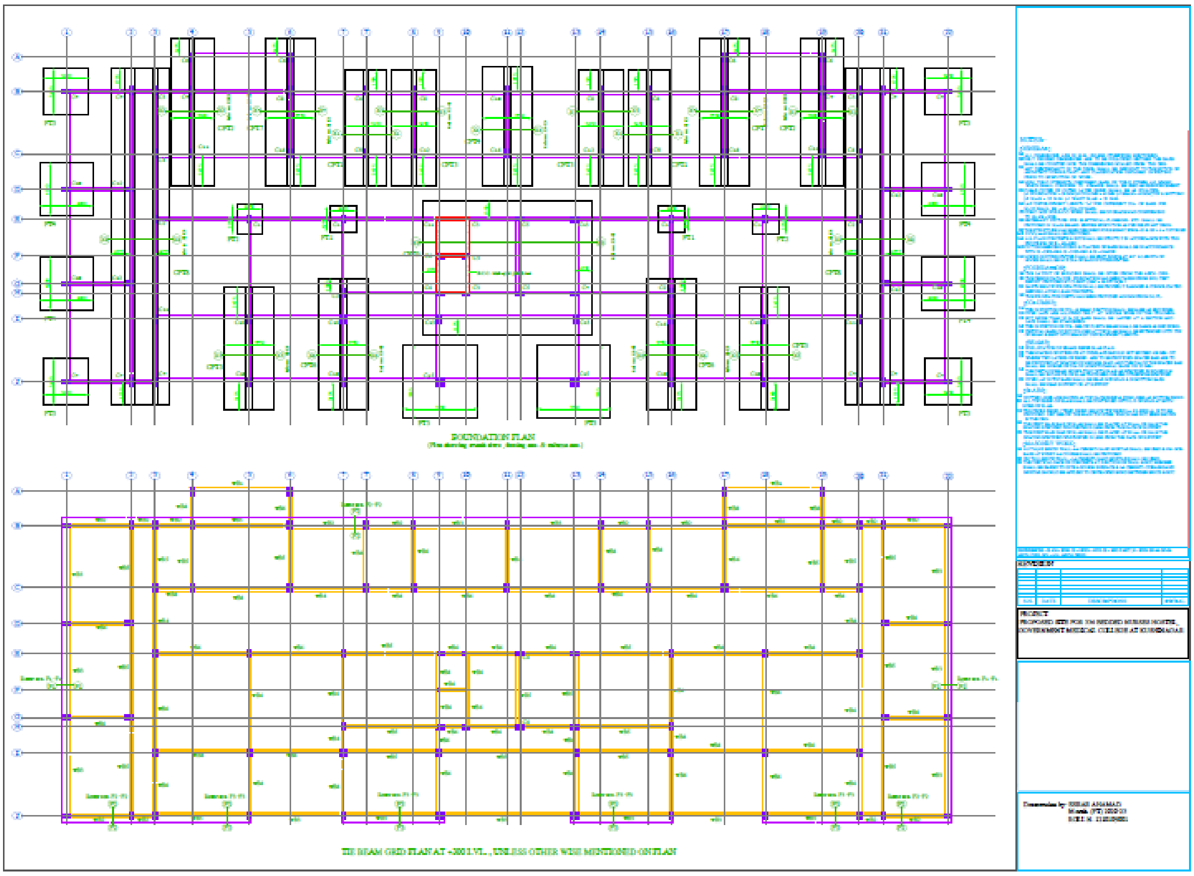


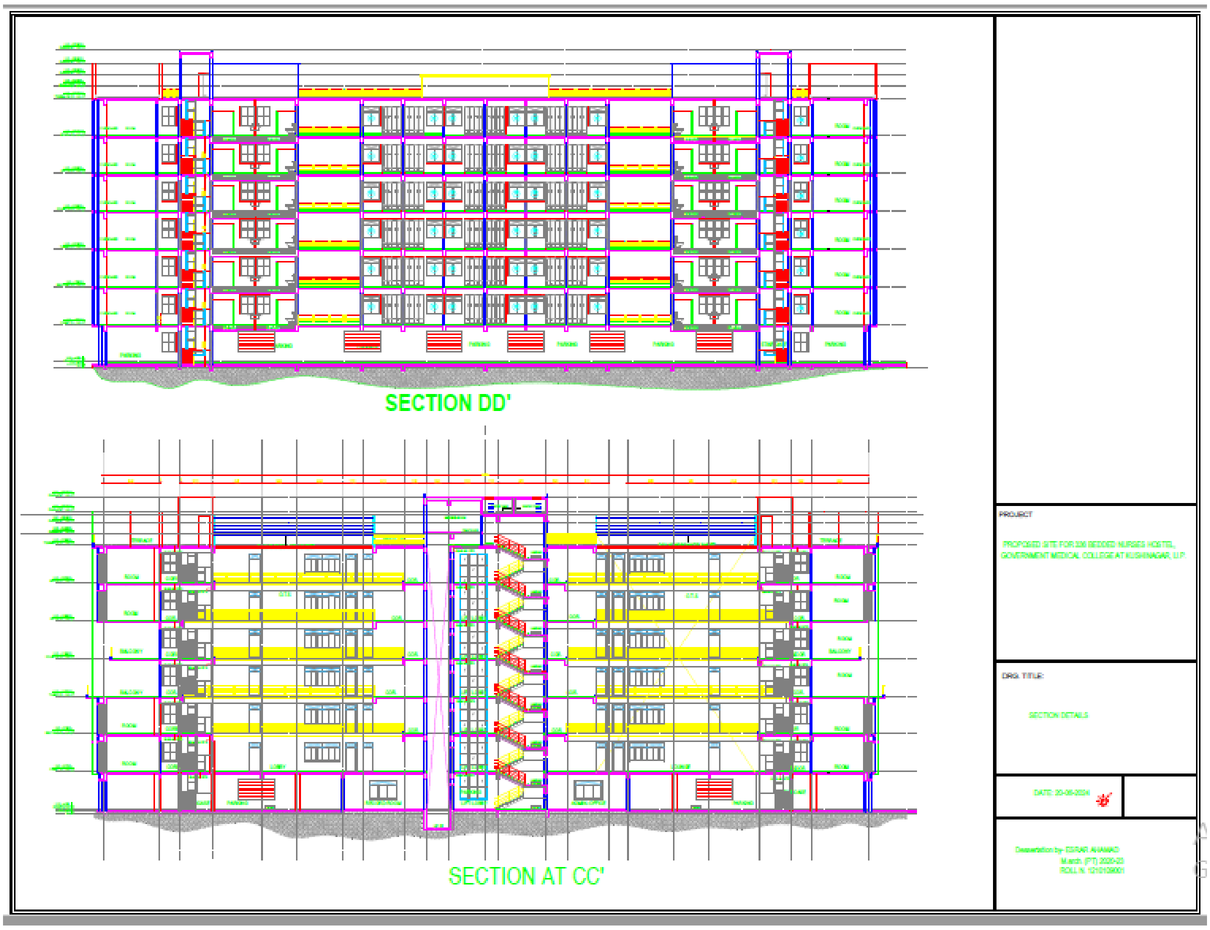





TERRACE FLOOR PLAN DETAILS
SIXTH PLAN DETAILS
PROJECT
DRG. TITLE
PLAN DETAILS


REAR ELEVATION
SIDE ELEVATION
SECTION BB'
PROJECT
DRG. TITLE:
SECTION DETAILS


FOUNDATION PLAN


SECTION DD'
SECTION AT CC'
PROJECT
PROPOSED SITE FOR 336 BEDDED NURSES HOSTEL,
GOVERNMENT MEDICAL COLLEGE AT KUSHINAGAR, U.P.
DRG. TITLE:
SECTION DETAILS
DATE:
Dissertation by-