JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Resilient Housing in Earthquake Prone Zone using Bamboo: Bihar

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Abstract

Earthquake is a natural event which has no fixed date and time. But whenever it occurs it destroys the human shelter and life. Due to various manmade disturbances to the nature, earthquake has become more often event. Due to highly dense built environment and violation of building by-laws in modern building the damage caused by Earthquake is more severe. India is divided in to Zone wise classification based on the severity of the earthquake. Zone –I to Zone – V being from less impact to high Impact. The aim of this research is to study in India about Resilient Housing construction techniques and Sustainable building material in earthquake prone zone.

India consists of five seismic zones. And if we have to go by the facts, many Indian megacities are on threat of earthquake. The psychological trauma of the earthquake survivor is beyond our thinking as the loose everything from home to family. In this situation they need a home and support to gain back their moral to fight with the situation and overcome.

The resilient construction technique with sustainable material may become a solution for quick fight back to the situation.

The Bamboo is a renewable resource and requires very less energy for construction. It does not require specialized tools for building construction and available at very less price compare to Conventional masonry structure, which makes it as cost effective material. Many research has been carried out to establish the mechanical strength of bamboo. Which proves that the bamboo is safe for building construction. The threats of durability also has been removed by using proper treatment. The Assam-type houses are best suitable example of bamboo houses. These houses demonstrate The simple geometry, low rise, grass infill, flat land are the ways to create cost effective earthquake resistant building.

Keywords : Resilient, Earthquake, Bamboo, Sustainable Material, Cost effective.

1. Introduction

Earthquake is something which is non predictable, it always brings a huge disaster in terms of built form and life loss. India has survived many major earthquake in last two decades and report claims the death in millions. In the Indian scenario multiple micro earthquakes are reported near the Himalayan belt on a daily basis, whereas in the intra plate region (Deccan plateau) few major earthquakes have been witnessed over the years. [1]

The amount of built form damage and life loss is an alarm for every individual who all are involved in field of construction. Also, it requires an awareness to the society to demand for earthquake efficient buildings. The Builders and contractors are need to be trained for resilient building construction techniques and sustainable material.

The majority of the Indian landmass (about 60%), is susceptible to moderate to very severe earthquakes [1]. Construction of earthquake proof building is nearly impossible, only earthquake resistant building can be constructed.[2] Light weight material, low rise building, sustainable approach these are few point by which, damage to built form and human life loss can be reduced.

2. Effect of earthquake on conventional building:

A regular conventional building is made using Cement concrete. The built form consist of Beam Slab and columns and wall. The foundation supports the RC structure and the RC frame is nothing but the RC columns with the joining beams, it takes part in the opposing the forces of the earthquake. The forces generated during the earthquake moves in a downward direction like from the slabs to the beams, from the beams to the columns and also to the walls and finally to the foundation, from the foundation they are scattered or spread along the ground. [2]

3. Methodology

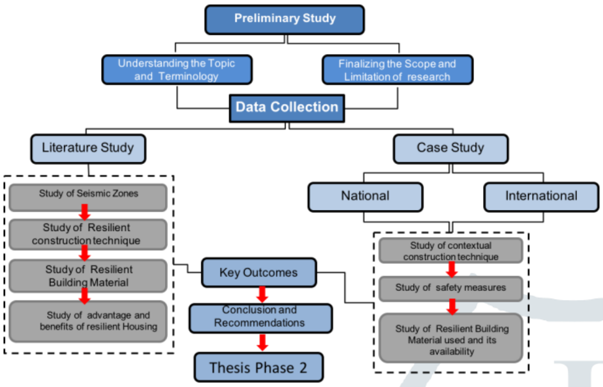


Chart: 1 – Methodology Flowchart

4. Aim and Objectives

The aim of this research paper is to study about Bamboo's potential as resilient building material for Earthquake prone zone.

Objectives are as follows:

- To study properties of bamboo.
- To study Sustainability aspect of Bamboo.
- To study the strength of Bamboo.
- To study the traditional style of site location.
- To propose housing for EWS earthquake survivor using Bamboo as resilient material.

5. Scope and Limitations

The study will focus on Bamboo as resilient building material and construction technique for earthquake survivor.

The study includes only Bamboo as resilient material for low rise housing community for EWS earthquake survivor.

6. Background

DISTRICTS LYING IN EARTHQUAKE HAZARD ZONE IV
(BASED ON THE VULNERABILITY ATLAS OF INDIA – 2ND EDITION, BMTPC)

ANDAMAN & NICOBAR ISLANDS	
ANDHRA PRADESH	
ARUNACHAL PRADESH	
ASSAM	
BIHAR	Banka, Begusarai, Bhagalpur, Bhojpur, Gopalganj, Jehanabad, Katihar, Khagaria, Lakhisarai, Munger, Nalanda, Purba-Champaran, Pashchim-Champaran, Patna, Samastipur, Saran, Siwan, Vaishali, Nawada, Sheikhpura, Jamui; Sheohar (22)

Table 1: Bihar Data

Source:https://www.bmtpc.org/disaster%20resistnace%20technolgies/ZONE%20IV.htm

As Per Bihar State Disaster Management Authority "Bihar is located in the high seismic zone that falls on the boundary of the tectonic plate joining the Himalayan tectonic plate near the Bihar-Nepal Border and has six sub-surface fault lines moving towards the Gangetic planes in four directions. Of the 38 districts of Bihar, 8 districts fall in seismic zone V of which 2 districts (Madhubani and Supaul) fall entirely in seismic zone V while 24 districts fall in seismic zone IV and 6 districts in seismic zone III with most districts falling under multiple seismic zones (i.e. either seismic zone V & IV or seismic zone IV & III). The state has in the past experienced major earthquakes; the worst was the 1934 earthquake in which more than 10,000 people lost their lives, followed by 1988 earthquake and recent earthquake was the Sikkim earthquake in September 2011."

Source: http://bsdma.org/Know-Your-Risk.aspx?id=2

Saturday, 25 April
April 2015 Nepal earthquake

The impact of Nepal earthquake in Bihar was massive. The earthquake occurred on 25 April 2015 at 11:56 a.m. NST (06:11:26 UTC) at a depth of approximately 15 km (9.3 mi) (which is considered shallow and its epicenter approximately 34 km (21 mi) east-southeast of Lamjung, Nepal, lasting approximately twenty seconds. Besides rendering millions homeless in Nepal it claimed thousands of lives and many people succumbed to their injuries. It also didn't spare the state of Bihar in terms of loss of life, properties and infrastructure. According of Department of Disaster Management Department, Government of Bihar.

Source:http://sambal.bihar.gov.in/document/view/704/Earthquake-in-Bihar--its-impact-and-outcome--25-26-April---12-May--2015-

Figure1: Bihar Nepal Border

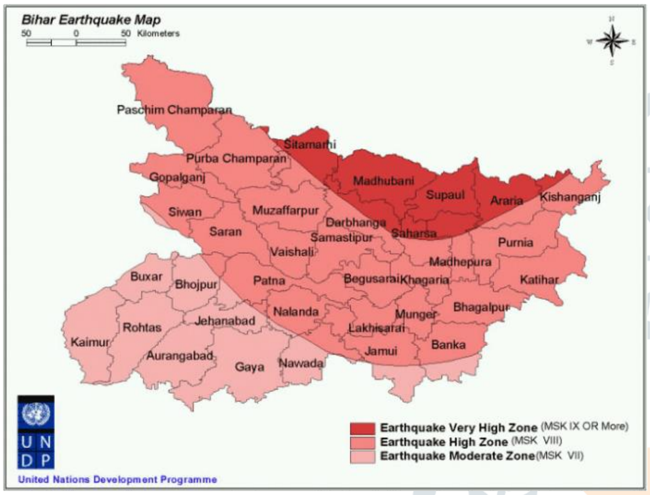


Figure2: Bihar Seismic Zone

There is an often-repeated saying, “Earthquakes don’t kill people, buildings do.” Although you can’t control the seismic hazard in the community where you live or work, you can influence the most important factor in saving lives and reducing losses from an earthquake: the adoption and enforcement of up-to-date building codes. Evaluating older buildings and retrofitting structural

and non-structural components also are critical steps. To survive and remain resilient, communities should also strengthen their core infrastructure and critical facilities so that these can withstand an earthquake or other disaster and continue to provide essential services.

7. Special Study as Sustainable material: Bamboo

7.1. Compressive strength test

Figure 3a: Red Brick Lab Test

Figure 3b: Red Brick Lab Test

Calculation:

Red Brick: Size = 225mm X 100mm | Area = 22500sqmm.

Applied Force = 280 KiloNewton.

Formula = (FORCE ÷ AREA)X 10^3

(280 ÷22500) X 1000 = **12.44 KN**

7.2. Concrete Block Strength Test

Figure 4: Conc. Block Lab Test

Calculation:

Cement Block: Size = 400mm X 200mm | Area = 80000sqmm.

Applied Force = 380 KiloNewton.

Formula = (FORCE ÷ AREA)X 10^3

(380 ÷80000) X 1000 = **4.75 KN**

7.3. Bamboo with Nodes strength Test

Figure 5a: Bamboo Lab Test

Bamboo Dia. :100 mm |

$$\textbf{Area} = \frac{\pi d^2}{4} = \frac{3.14 \times 100^2}{4} = \textbf{7850 sqmm}$$

Applied Force = 100 KN

Formula = (FORCE ÷ AREA)X 10^3
(100 ÷7850) X 1000 = **12.73 KN**

7.4. Strength Test: Comparative Analysis

SL NO	Material	Area	Force applied	Compressive Strength
1	RED BRICK	22500 sqmm	280 KN	**12.44 KN/SQMM**
2	CEMENT BLOCK	80000 sqmm	380 KN	**4.75KN/SQMM**
3	BAMBOO WITH NODE	7850 SQMM	100 KN	**12.73 KN/SQMM**
4	BAMBOO WITHOUT NODE	7850 SQMM	40KN	**5.09 KN/SQMM**

7.5. Bamboo Tensile strength Test

Figure 5b: Bamboo Lab Test

Tensile strength of bamboo is **150 N/sqmm**

7.6. Bamboo Bending Strength Test

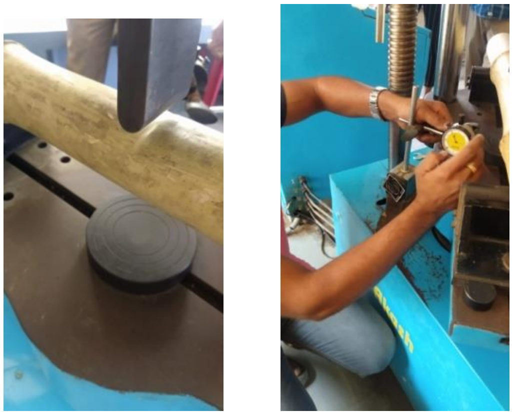
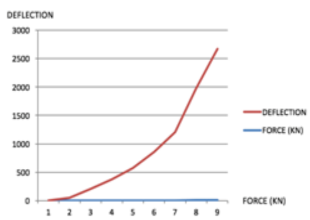


Figure 5c: Bamboo Lab Test

7.7. Bamboo Bending Strength Test readings

SL NO	FORCE (KN)	DEFLECTION
1	1	0
2	2	50
3	3	205
4	4	370
5	5	570
6	6	850
7	7	1200
8	8	1970
9	8.2	2660



Graph 4.1. Lab Test – Deflection Graph

Table 2: Bamboo Lab Test

8. Material Analysis:

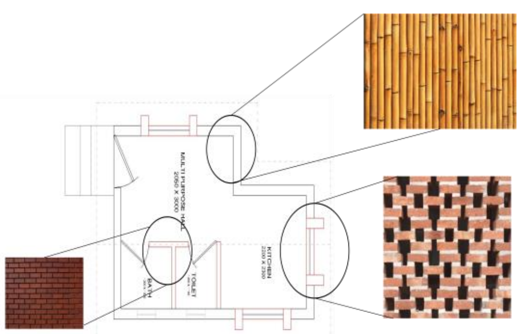


Figure 6: Bamboo and brick wall

8.1. Roof: MODROOF

Corrugated cement and metal sheets are the most widely used roofing materials in low-income communities all over the world, but these options are uncomfortable and dangerous:

- Heavy weight- Not suitable for earthquake prone zone
- Unbearably hot in the summer
- Loud and leaky during monsoon season
- Break frequently, causing injury
- Require costly, time-intensive repairs
- Contain toxic chemicals like asbestos

Corrugated metal and cement roofing lead to adverse health effects and reduced quality of life. The only other option on the market is a concrete roof, which is simply not affordable.

8.2. Road: Waste Tire

A tire that can no longer serve its original intended purpose is a waste tyre.

- A waste tire out typically consists of rubber compound (70.%), steel (16.5%), and nylon/fiber (5.5%).
- The most common applications for scrap tires use either whole or shredded tires or granulated rubber derived from tires. The main end-markets for scrap tires are tire-derived fuel, road constructions & ground rubber applications.

As per MORTH directives for NHAI that an approx. 30 km road is to be constructed every day. Keeping in view the above, an approx. 750 MT of bitumen is to be used for wearing course every day. If Waste tyre crumb is to be used with bitumen for wearing course, an approx. 250 no's of tyre waste can be consumed in roads every day or 100,000 no's of waste tyre annually.

9. Literature Study and Case Study

- Literature study done based on few important parameter as follows :
- Cultural Study
- Local Material study
- Social acceptance study
- Need of time analysis
- Cost analysis

Case study was done keeping requirement in mind:

Such as Bamboo strength test

Market Analysis for final cost

User requirement

Present problems

9.1. Site Selection and Analysis

Figure 7: Site Surrounding features

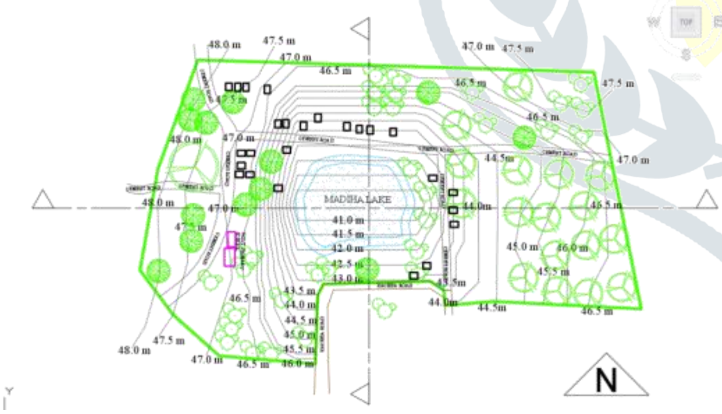


Figure 8: Site Contour

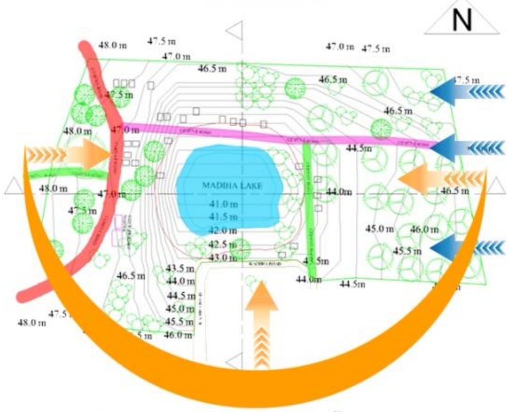


Figure 9: Site climatic factor

10. Design Development

Thrust area Identification

As per my study from Literature Study, Case Study and Lab Test, I conclude that the Bamboo is Light yet Strong, Hard yet resilient material, Looks elegant yet cost effective, Joinery details looks complex yet simple to work with.

These are the properties required for earthquake prone zone. Due to its less weight, the threat of life loss reduced. Same material can be reused to rebuilt the houses.

Very less expenditure to rebuilt and repair.

Therefore, for my thesis thrust area would be Bamboo as Construction Material.

10.1. Design Requirement

- Economically Weaker Section (EWS)
- Monthly Income Less than Rs. 5000/-

According to Article 21 of the Constitution of India, each and every citizen has a right to shelter where he can live and prosper. Even though shelter is a fundamental right in our

Chart: 2 – Design Requirement

country, still a large chunk of Earthquake survivor live in inhabitable condition.

One of the Major issue is The spaces created don't match with the lifestyle of the poor. In most cases the family size is too large to live a healthy life in the space provided.

Chart 2: Design requirement

10.2. Area Statement:

SL NO	DESCRIPTION	NBC (SQM)	LITRATURE STUDY (SQM)	CASE STUDY (SQM)	CONCLUSION (SQM)
1	Plot size	----	40-45	30-45	50 (Incremental)
2	Built up	----	20-25	20-30	20
3	Primary School	2000	1500	----	1500
4	Skill Development Center	2000-6000	1200	----	1500
5	Police Out Post (Home Guard)	100	----	----	100
6	PHC	250-670	200-300	----	250
7	Community Hall	750	700-800	500	700
8	Temple	----	----	----	800 (Existing)
9	Common Toilet	0.9	0.9	0.9	0.9
10	Transformer Yard	500	----	300	500
11	Play Ground	1200-5000	----	----	1750
12	Garbage yard	----	----	100	100

Table 2: Required area details

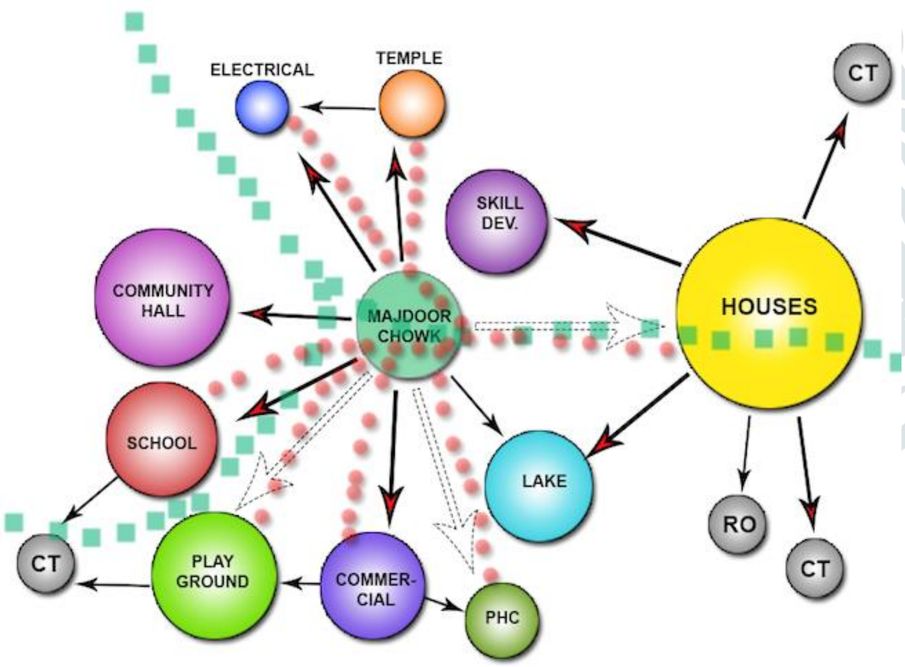


Figure10: Bubble Diagram

10.3. Design drawing

Figure11: Master Plan

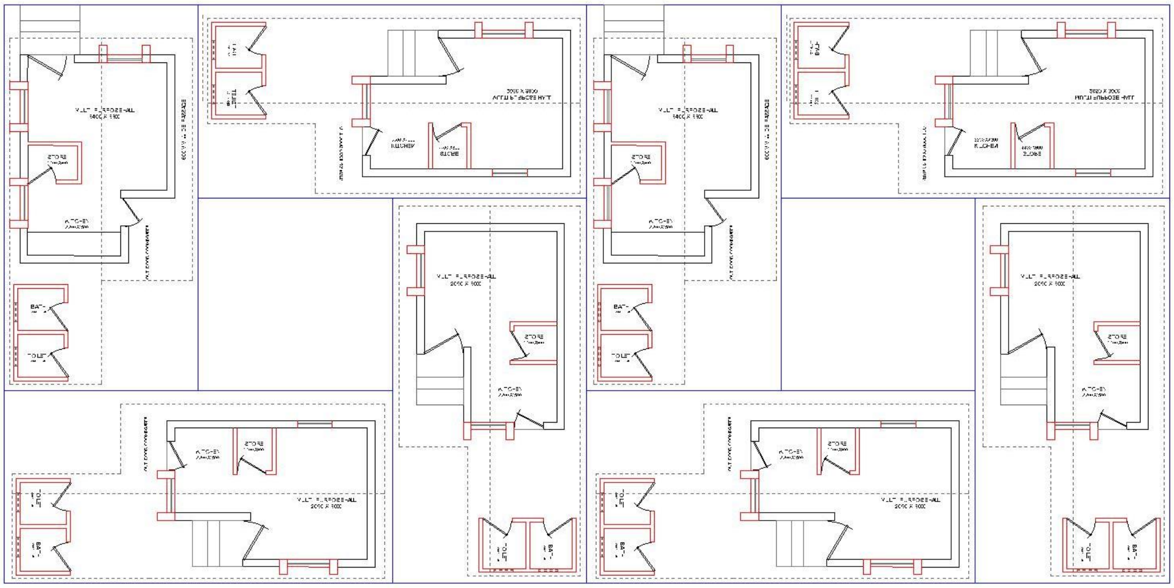


Figure12: Cluster Plan

Figure12: Cluster Section

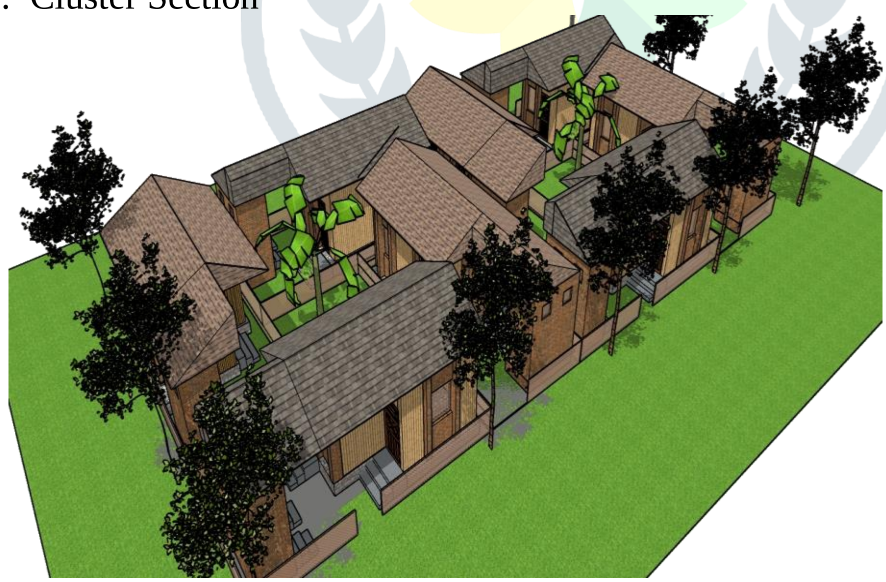


Figure13: Cluster Aerial View

Figure14a: Cluster Solar Analysis

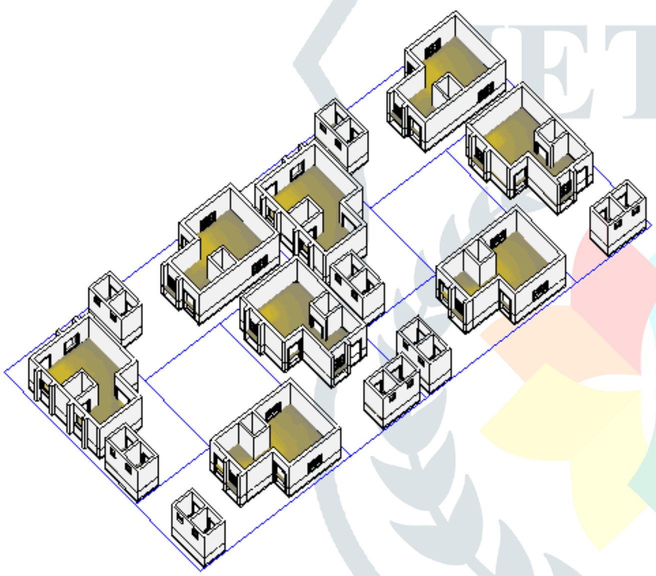


Figure14a: Cluster Solar Analysis

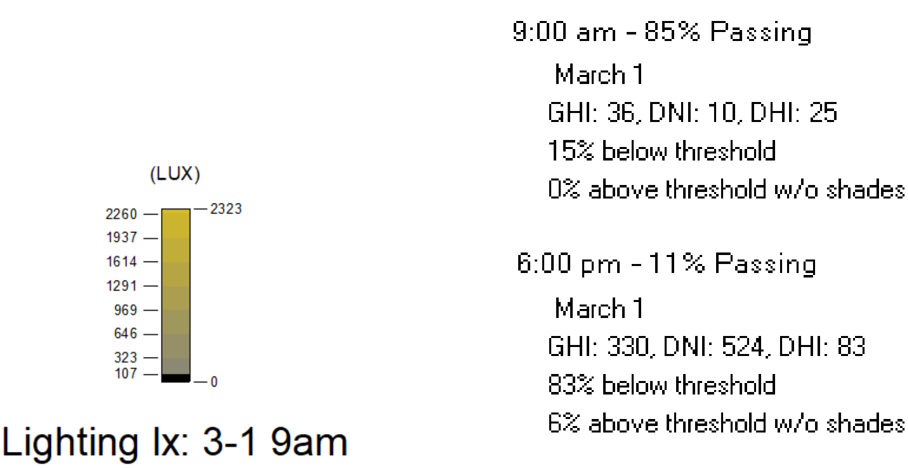


Figure15: Cluster Lighting Analysis

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