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RETROFITTING OF LOW STRENGTH MASONRY BULDING BY SPLINT AND BANDAGE METHOD AND PERFORMANCE EVALUATION

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Abstract— *the fundamental Objective of this study is to compare the seismic performance of the unreinforced masonry building with retrofitted building using splint and bandage method as it is neither practical nor feasible to demolish all the existing buildings and construct new to meet seismic safety as cost, importance and vulnerability of structure major role. This studies focus on the splint and Bandage method of retrofitting, which decrease the vulnerability of structure in major failure mode (out of plane failure and in-plane failure mode). With the application of splint and bandage on the building, the performance of building was improved. The base shear and displacement of the structure was reduce whereas moment resisting capacity and shear strength was increased.*

Keywords— Splint and bandage, Unreinforced masonry, Retrofit, Performance level

I. INTRODUCTION

Nepal has a long history of devastating earthquake occurring at the interval of 80-90 years. As Nepal lie in the subduction of Indian plate underneath the Eurasian Plate resulting in one of the most seismically active zone in the world. This subduction zone accumulate the energy from the convergence of the zone, on reaching its limit, it release the energy in the form of seismic energy. Nepal has experience the lots of major earthquake in its history, the latest one being the Gorkha Earthquake on April 25, 2015 of magnitude 7.8 Mw. This earthquake results in 8857 casualties, 22,304 injuries nearly 800000 buildings were collapsed causing around $10 billion losses.

Earthquake doesn't itself kill the people but the destruction of the man-made structures, buildings, bridge, towers due to the earthquake do. After the earthquake lots of seismic vulnerability assessment were done throughout the country. Based on those studies most of the buildings that were collapse were building of unreinforced masonry which were constructed by the local masons without any help from the professional expert. There still exist masonry buildings that are still standing, for those building are highly vulnerable to future earthquake as the construction were done based upon the local masons. For such building, to strengthen their structural performance to prevent those from immediate failure there 'exist the practical solution to increase the seismic safety standard by upgrading their level of safety by retrofitting. It is neither practical nor feasible to demolish all the existing buildings and construct new to meet seismic safety as we cost plays one of the major roles. So depending upon the cost, important and vulnerability of structure different retrofitting techniques were applied.

This studies focus on the splint and Bandage method of retrofitting, which decrease the vulnerability of structure in major failure mode (out of plane failure and in-plane failure mode). In the Splint and Bandage method of retrofitting, the vertical and horizontal band are added near the opening and at the corner. The band are applied inside and outside of the structure and are connected by anchorage bar. The Specific objective of this study are to study the behavior of unreinforced masonry building under seismic load, before and after the application of retrofitting techniques (Splint and Bandage method) under seismic load.

II. METHODOLOGY

The date required for the analysis was taken in account. The dimension of building were assumed whereas the material properties and load to be applied are taken into account through IS codes and NBC. The modelling was done in Sap2000 for unreinforced masonry building required were taken, then the model was revised for retrofitting. The Splint and bandage band are model as sectional layered section, and the rebar were assigned as thin sheet as there is no

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appropriate way to assignment the rebar in the section property. The required date were calculated and comparisons were made between the model on base shear, displacement, moment capacity and compressive stress capacity. The comparison were done for single wall only.

Calculation of Seismic Weight

Tables-1

			Unretrofitted	Retrofitted	
Seismic zone		Cl 6.4.2, Table 2	Zone V	Zone V	
Seismic Zone f	Z	5.4.2, Tabl	0.36	0.36	
Structure type		Table6			
Importance fact	I	6.4.2, Tab	1.0	1.0	
Lateral load resisting system		Draft code Cl 6.4.2,			
Response reduction factor	R	Draft code Cl 6.4.2,	1.500	2.500	
Height of the building	h	Refer dwg	2.840	2.840	m
Dimension Along X	D_x	Refer dwg	3.120	3.120	m
Dimension Along Y	D_y	Refer dwg	4.730	4.730	m
Time period along X,	$T_x = 0.09h/\sqrt{D_x}$	Cl 7.6.2	0.145	0.145	sec
Time period along Y	$T_y = 0.09h/\sqrt{D_y}$	Cl 7.6.2	0.118	0.118	sec
Soil type		Type III (Soft soil)			
Response acc. Coeff. along X	$(Sa/g)_x$	Cl 6.4.5, fig. 2	2.5	2.5	
Response acc. Coeff. along Y	$(Sa/g)_y$	Cl 6.4.5, fig. 2	2.5	2.5	
Design Horizontal Seismic	$A_{hx}=ZIS_a/(2Rg)$	Cl 6.4.2	0.3000	0.1800	
Design Horizontal Seismic	$A_{hy}=ZIS_a/(2Rg)$	Cl 6.4.2 $ZIS_a/(2Rg)$	0.3000	0.1800	

NBC 102:1994 Unit Weight of Material

(IS 875 Part 1 is used as referred by NBC 102:1994)

Steel : 7850 Kg/m^3

Brick Masonry : 19.00 KN/m^3

Poisson's Ratio (ν) : 0.30

Modulus of Elasticity (E) :1351.7 N/mm^2

RCC : 7850 Kg/m^3

NBC 103:1994 Occupancy Load

(IS 875 Part 2 is used as referred by103:1994)

Floor Finish : 1.0 KN/m^2

Roof : 1.5 KN/m^2

Load Combination: For Working Stress method As per NBC 105:

DL+LL
0.7DL+EQx
0.7DL-EQx
0.7DL+EQy
0.7DL-EQy
DL+LL+EQx
DL+LL-EQx
DL+LL+EQy
DL+LL-EQy

Figures and Tables

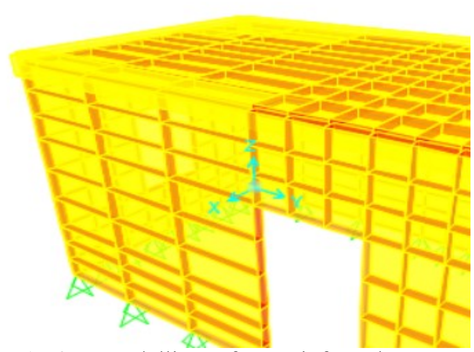

Fig 1: 3D Modelling of Unreinforced Masonry Building

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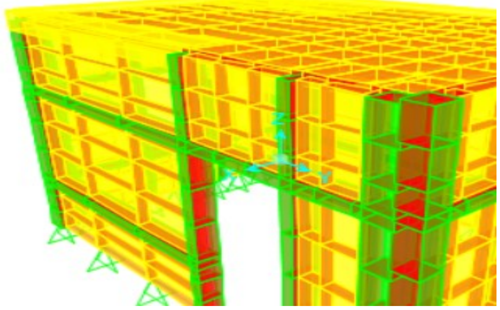

Fig 2: 3D Modelling of Retrofitted Building

III. Result and Discussion

For the seismic behavior of the unreinforced masonry and retrofitted building, the linear static analysis were performed in SAP2000. For lateral loading seismic coefficient method as IS 1893:2002 was applied. The seismic response of structure of single wall was found out in terms of maximum displacement, base shear, shear stress, compressive stress and bending stresses in the masonry building for each model. The result were presented in terms of tabular.

Table-2

Parameters	Control Model	Retrofitted Model	Unit	Remarks
Length	4.84	4.84	m	Application of splint and bandage both ways with 50 mm thick M20 mortar , width of 110mm. and 8mm rebar
Height	2.84	2.84	m	
Thickness	0.11	0.11	m	
Story Drift	1.08	0.354	mm	Decrease in story drift
Base shear	59.245	40.25	KN	Decrease in Base Share
Shear Stress	0.02	1.02	N/mm²	Shear Strength has increased.
Compressive stress	0.34	0.502	N/mm²	Increase in Compressive stress capacity
Moment (M11)	0.17	1.26	KN/m²/m	Increase in in-plane moment capacity
Moment (M22)	0.3	5.277	KN/m²/m	Increase in out-plane moment capacity

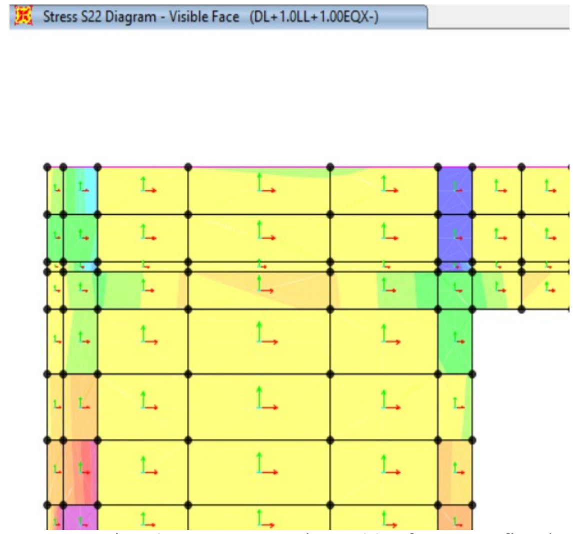

Fig 3: Stress under s22 for retrofitted building

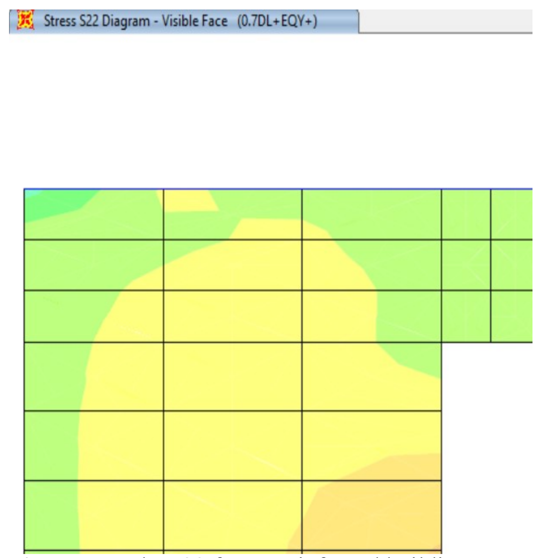

Fig 4: Stress under s22 for Unreinforced building

The inter-storied drift of wall was decreased 72% after retrofit. The base shear of the retrofitted building was reduced by 32%.The compressive stress and moment capacity of retrofitted building was increased, so, as the stress and moment was also increased. The most moment and stress were taken by split and bandage as shown in fig. above.

IV. Limitation :

1. No consideration of bond strength between the brick unit, as modelling of such bond is not possible in the sap2000.
2. No consideration of anchorage between the two bands, as the bond stress also increase the strength.

3. The model of rebar was done as thin sheet rather than modelling the rebar.
4. The analysis was done with linear static method only. For the better performance and evaluation nonlinear static analysis and performance based analysis could have been done.

V. CONCLUSION:

The splint and Bandage method of retrofitting, decrease the vulnerability of structure in major failure mode (out of plane failure and in-plane failure mode). In the Splint and Bandage method of retrofitting, the vertical and horizontal band are added near the opening and at the corner as the part of the building are more vulnerable to the damage. The band are applied inside and outside of the structure and are connected by anchorage bar. With the application of splint and bandage on the building, the performance of building was improved. The stress and moment concentration after the application of band were mostly concentrated over the area of band, since the band have move capacity than the masonry structure, and it was able to absorb the stress and making the building more susceptible to damage during the earthquake loading. Fig-3 and fig-4 we can see the stress concentration over the unreinforced masonry and retrofitted model. The base shear and displacement of the structure was reduce whereas moment resisting capacity and shear strength was increased.

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