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Comparative Analysis of Steel Building on Sloping Ground for Different Angle

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ABSTRACT: Generally, all buildings are constructed on horizontal plain level ground. In the hilly region having sloping ground it is hard to build the multistory structures. The constructions of the building now days are progress on sloping ground due to lack of horizontal plain level ground. These hill regions are the most hazardous view shows sometimes due to some natural calamities like land sides and seismic activity. The earthquake is the one of the major factors is consider on the sloping and mountainous areas. Thus, due to growing level of heavy population the biggest reason of construction done on mountainous areas. The study of earthquake resistant of building on sloping ground becomes popular to prevent the loss of life, property during earthquake ground motion. Different height of columns is present in building on hilly slopes in a same story, as a result more forces are attracted during earthquake ground motion by short columns and damage occurs.

KEYWORDS: Sloping Ground, Steel Structure, Level Difference, Response Spectrum Method, Base Shear, Fundamental Natural Period.

I. INTRODUCTION

The economic growth and rapid urbanization in hilly region has accelerated the real estate development. Due to this, population density in the hilly region has increased enormously. Therefore, there is popular and pressing demand for the construction of multistorey buildings on hill slope in and around the cities. It is observed during the past earthquakes, buildings in hilly regions have experienced high degree of damage leading to collapse though they have been designed for safety of the occupants against natural hazards. Hence, while adopting practice of multistorey buildings in these hilly and seismically active areas, utmost care should be taken for making these buildings earthquake resistant.

Steel structure is a metal structure which is made of structural steel components connect with each other to carry loads and provide full rigidity. Because of the high strength grade of steel, this structure is reliable and requires fewer raw materials than other types of structure like concrete structure and timber structure. Structural Steel is steel construction material which fabricated with a specific shape and chemical composition to suit a project's applicable specifications. Common shapes include the I-beam, Channels, Angles and Plate. In modern construction, steel structures are used for almost every type of structure including heavy industrial building, high-rise building, equipment support system, infrastructure, bridge, tower, airport terminal, heavy industrial plant, pipe rack, etc.

II. LITERATURE REVIEW

The present work is aimed at comparative study of analysis of Multi-Storeyed Steel Structure on Sloping Ground with and without Bracing. Various studies have been carried out till date for Sloping ground with RCC structure but none of them compare steel structure on sloping ground.

Reshama Philip (2018) They analyzed a (16x16) m, G+5 building on slope 0, 5, 10, 15, 20 degree. The aim of this work was to find out the effect of lateral loads on short column. The G+5 building done Sap-2000 with seismic Zone IV and Type II soil. In this project its focus on short column because short column is attracted large earthquake force as compare regular storey column. They analysis the two similar building. With Apply Push over analysis and Response

Spectrum Method. They find the RC column damage by large stresses in short stiff column. The torsional effect is increase in sloping ground.

Samir Helou (2019) They are analysis the G+10 building by infill wall provided at center at column line of the periphery of the column. The seismic analysis base on Response Spectrum Method and assumed Importance Factor 1, Zone III. The structure is G+10 RCC having 4 bay Y direction and 5 Bay X direction 5 m spacing and 3 m height. The structure is Step-Back, Set-Back and Step-Back done on ETABS. They calculate the Time Period, Displacement, etc. The conclusion of the result it's control the lateral deflection.

Aswin Nair et al. (2021) The varying height of column the shear force and torsional moment is attract more and it is distributed unequal. They model the two different building in ETAB v 9.0 by using Response Spectrum Method. The first model is step back and set back RCC building and second is step back and set back RCC building with provide shear wall in four corners. The building is RCC with foundation depth is 1.5-meter, story height is 3m and slopes consider 26 degrees. They dynamic parameter consider ns at foundation level, fundamental time periods, maximum top storey displacements, storey drifts and storey shear in buildings. They observed the displacement is reduced by providing shear wall.

Dhiraj Ahiwale et al. (2020) In this research paper they study the Fluid Viscous Dampers (FVD) for reducing the seismic response of high-rise steel building. They conducted G+30 steel building rest on 25-degree slope with FVD of various capacities and analyzed with different Time History function. The FVD capacity is 250, 500, 750 and 1000 kN. The Time history function is Imperial valley, Friuli Italy Gazli USSR and Bhuj. This study is done on Etabs and they analysis the parameter Story Deflection, Story Drift and base Shear. The building plan consists of total plan area of 20m x20m and considered to be located in zone V and Response reduction factor 5 with Soil type II (Medium). They study the step back building base shear, Displacement, Drift increase when capacity increased. They observed higher damper can be used to improve performance of building.

III. METHODOLOGY

In this study, a comparative analysis Steel structure frame with different angle where structure is (G+10), (G+20), and (G+30) floor for commercial used where floor to floor height 3.5m. The building rest on sloping in one side ground where slope is 10, 20, 30 and plain ground under the seismic and wind load. The building frame is step back. The structure should be analysis with and without Bracing system.

The result of this analysis will include base shear, Displacement, Fundament natural time period. The conclusion will be finding out and compared with different configuration. At the end, a suitable configuration of building to be used in hilly region is suggested.

IV. STRUCTURAL MODELLING

In this study, structure will be model for the following cases: 1.) STEEL Frame (G+10) building on plain ground. 2.) STEEL Frame (G+20) building on plain ground. 3.) STEEL Frame (G+30) building on plain ground. 4.) STEEL Frame (G+10) step back building on sloping 10 degree. 5.) STEEL Frame (G+20) step back building on sloping 10 degree. 6.) STEEL Frame (G+30) step back building on sloping 10 degree. 7.) STEEL Frame (G+10) step back building on sloping 20 degree. 8.) STEEL Frame (G+20) step back building on sloping 20 degree. 9.) STEEL Frame (G+30) step back building on sloping 20 degree. 10.) STEEL Frame(G+10) step back building on sloping 30 degree. 11.) STEEL Frame(G+20) step back building on sloping 30 degree. 12.) STEEL Frame(G+30) step back building on sloping 30 degree. 13.) STEEL Frame with X Bracing at corner (G+10) building on plain ground. 14.) STEEL Frame with X Bracing at corner (G+20) building on plain ground. 15.) STEEL Frame with X Bracing at corner (G+30) building on plain ground. 16) STEEL Frame with X Bracing at corner (G+10) step back building on sloping 10 degree. 17.) STEEL Frame with X Bracing at corner (G+20) step back building on sloping 10 degree. 18.) STEEL Frame with X Bracing at corner (G+30) step back building on sloping 10 degree. 19.) STEEL Framewith X Bracing at corner (G+10) step back building on sloping 20 degree. 20.) STEEL Frame with X Bracing at corner (G+20) step back building on sloping 20 degree. 21.) STEEL Framewith X Bracing at corner (G+30) step back building on sloping 20 degree. 22.) STEEL Frame with X Bracing at corner (G+10) step back building on sloping 30 degree. 23.) STEEL Frame with X Bracing at corner (G+20) step back building on sloping 30 degree. 24.) STEEL Framewith X Bracing at corner (G+30) step back building on sloping 30 degree.



V. PRELIMINARY DATA

Following are the data assumed for carrying out this study, 1.) Length in X direction = 17.5m 2.) Length in Y direction = 17.5m 3.) Typical storey height = 3.5m 4.) No. of Storey = G+10, G+20 and G+30 5.) Bay spacing in X direction= 3.5m 6.) Bay spacing in X direction = 3.5m.

Geometry of Building

Geometry of Building

Slab		150 mm Thick
Beam		ISHB 400-1
Column For G+30	GF to F05 - F05 to F10 - F10 to F15 - F15 to F20 - F20 to F25 - F25 to F30 -	ISWB 600 - 2 - 400 - 40 ISWB 600 - 2 - 400 - 32 ISWB 600 - 2 - 400 - 20 ISMB 600 - 320 - 16 ISMB 550 - 250 - 12 ISHB 500 - 250 - 10
Column For G+20	GF to F05 - F05 to F10 - F10 to F15 - F15 to F20 -	ISWB 600 - 2 - 400 - 20 ISMB 600 - 320 - 16 ISMB 550 - 250 - 12 ISHB 500 - 250 - 10
Column For G+10	GF to F05 - F05 to F10 -	ISMB 550 - 250 - 12 ISHB 500 - 250 - 10

Seismic Load and Wind Load

Seismic Load and Wind Load

Seismic Loading	Wind Load
Zone factore (z)= 0.16	Wind speed=44m/s
Importance factor (i)=1.2	Risk factor (k1) =1
Soil type = i	Terrain roughness (k2) =1
Damping of structure=5%	Topography factore (k3) = it's depends on slope of ground
Response factore(omrf) (r)=3	Importance facore (k4) =1

For Topography Factor K3

Calculating K3 for slope 10-degree Slope for G+10, G+20 and G+30

G+10	G+20	G+30
H = 35m	H = 70 m	H = 105 m
$C = 1.2x(Z/L)$ $= 1.2x(150/450) = 0.4$	$C = 1.2x(Z/L)$ $= 1.2x(150/450) = 0.4$	$C = 1.2x(Z/L)$ $= 1.2x(150/450) = 0.4$
Le = L = 450 m	Le = 450 m	Le = 450 m
UPWIND $(X/Le) = (350/450) = 0.78$ $(H/Le) = (33/450) = 0.073$	UPWIND $(X/Le) = (350/450) = 0.78$ $(H/Le) = (66/450) = 0.146$	UPWIND $(X/Le) = (350/450) = 0.78$ $(H/Le) = (102.3/450) = 0.22$



$S_o = 0.1$	$S_o = 0.1$	$S_o = 0.1$
$K3 = 1 + C \times S_o$ $= 1 + 0.4 \times 0.1$ $= 1.04$	$K3 = 1 + C \times S_o$ $= 1 + 0.4 \times 0.1$ $= 1.04$	$K3 = 1 + C \times S_o$ $= 1 + 0.4 \times 0.1$ $= 1.04$

Calculating K3 for slope 20, 30-degree Slope for G+10, G+20 and G+30

G+10	G+20	G+30
H = 35m	H = 70 m	H = 105 m
C = 0.36	C = 0.36	C = 0.36
Le = L = 450 m	Le = 450 m	Le = 450 m
UPWIND $(X/Le) = (350/450) = 0.78$ $(H/Le) = (33/450) = 0.073$ $S_o = 0.1$	UPWIND $(X/Le) = (350/450) = 0.78$ $(H/Le) = (66/450) = 0.146$ $S_o = 0.1$	UPWIND $(X/Le) = (350/450) = 0.78$ $(H/Le) = (99/450) = 0.22$ $S_o = 0.1$
$K3 = 1 + C \times S_o$ $= 1 + 0.36 \times 0.1$ $= 1.036$	$K3 = 1 + C \times S_o$ $= 1 + 0.36 \times 0.1$ $= 1.036$	$K3 = 1 + C \times S_o$ $= 1 + 0.36 \times 0.1$ $= 1.036$

Fundamental natural period (Ta): (Clause 7.6.2. IS 1893 2016)

Table 3.4.1 Plain Slope Ta

	H (m)	Pain slope (Ta)=0.085*h ^{0.75}
G+10	33	1.22
G+20	66	2.06
G+30	99	2.79

Table 3.4.2 10 Degree Slope Ta

	H (m)	10 Degree slope (Ta)=0.085*h ^{0.75}
G+10	30.25	1.18
G+20	63.25	2.02
G+30	96.25	2.75

Table 3.4.3 20 Degree Slope Ta

	H (m)	20 Degree slope (Ta)=0.085*h ^{0.75}
G+10	27.41	1.09
G+20	60.41	1.95
G+30	93.41	2.69

Table 3.4.4 30 Degree Slope Ta

	H (m)	30 Degree slope (Ta)=0.085*h ^{0.75}
G+10	24.13	0.99
G+20	57.13	1.87
G+30	90.13	2.62

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