Study of Reliability of V-Type Bracing System to Avoid Progressive Collapse of Structure

Nishant Pundalik Asawale[1], Prof.N.P.Phadatare[2]

Structural Engineering Department, PVPIT Budhgaon

[1]M.Tech Student

[2]Associate Professor

Abstract— **From past few years because of the demand of the customers building with soft storey are constructed, it is convenient for parking purpose. While parking any vehicle there are chances that any vehicle may collide with the column and column may fail which may leads to progressive collapse of structure. Also there is threat of terrorist attack if they damage the critical column then it trigger a chain reaction which then results in failure of entire structure. To avoid progressive collapse V-type bracing systems can be used. As bracing system contribute in resisting lateral load it can also contribute in resisting the impact of progressive collapse. Analysis and design of building is carried out using computer program ETABS.**

Keywords—— **Progressive collapse, critical column, soft storey, diagonal bracing systems, chain reaction**

I. INTRODUCTION

Progressive collapse can be defined as the collapse of all or large part of a structure due to damage of relatively smaller part of a structure. It is also called as disproportionate collapse because as compare to first collapse the result is very large. To avoid progressive collapse due to failure of critical column in outer bays bracing systems can be used. As bracing systems significantly contribute in resisting lateral loads therefore it can also contribute in resisting the impact of progressive collapse due to removal of column in outer bays.

II. ANALYSIS PROCEDURE

The U.S. General Service Administration developed the progressive collapse analysis and design guideline for the Federal office building and major modernization projects to ensure that the potential of progressive collapse is addressed in design, planning and construction.

According to G.S.A. there are two methods of analysis of progressive collapse namely linear static analysis and linear dynamic analysis. Progressive collapse analysis is performed by instantly removing one or several columns here while analysis of any structure demand capacity ratio is key factor because progressive collapse phenomenon is based on depend on demand capacity ratio.

According to guidelines by G.S.A. the linear static analysis procedure can be applied upto 10 storey G.S.A. guideline have specified the following load case for static linear analysis procedure, load = 2(DL+0.25LL)

The performance of structure is evaluated by DCR, which should not exceed 2 for regular structure and 1.5 for irregular structures or else they are considered as severely damaged or failure. GSA has defined DCR as below,

DCR = QUC/QCE

QUD = Acting force (demand) determined in component   (moment)

QCE = Expected un-factored moment carrying capacity of the component
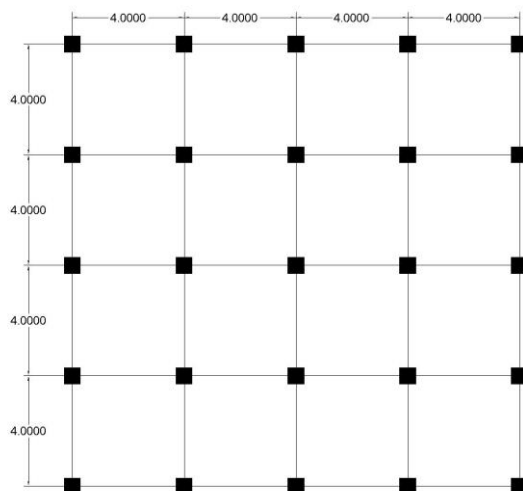
III. BUILDING DESIGN (NORMAL LOADING)

Fig. 1 Building Plan

A. Building specifications are as follows,

Beam size – 300 X 600 mm

Slab – 130 mm

Columns for Ground, 1st, 2nd, 3rd floor – 600 X 600 mm

Columns for 4th and 5th floor – 400 X 400 mm

Columns for 6th and 7th floor – 300 X 300 mm

Seismic Zone – Zone II

Zone factor 0.1

From the building design in ETABS we get the reinforcement of each member from which the unfactored moment carrying capacities of beams can be calculated.
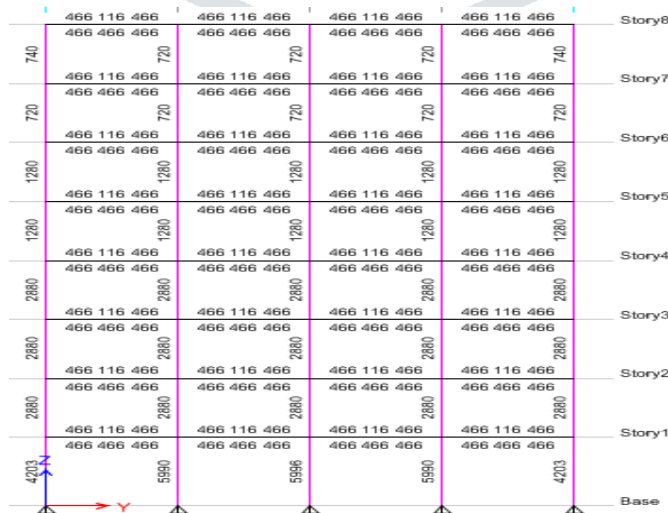

Fig. 2 Reinforcement Details

From the reinforcement details ultimate moment carrying capacities are calculated.
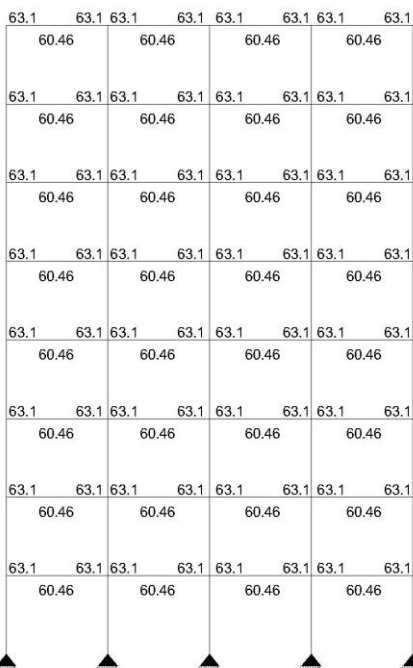
Fig. 3 Moment Carrying Capacities

IV. COLUMN REMOVAL SCENARIO

According to GSA guidelines following positions in the given building have the critical columns,

Case1) Middle column of each side
Case2) Corner column
Case3) Adjacent to corner column

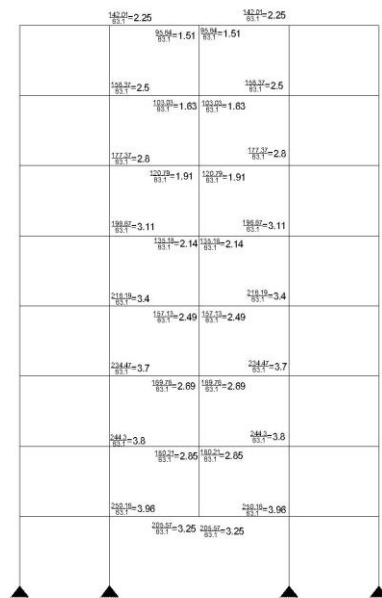The demand capacity ratio after each case is shown in following figures

Fig. 4 Case1)Middle column removal

$\frac{152.4}{63.1} = 2.41$

$\frac{67.47}{63.1} = 1.06$

$\frac{174.44}{63.1} = 2.76$

$\frac{81.86}{63.1} = 1.29$

$\frac{198.77}{63.1} = 3.15$

$\frac{109.77}{63.1} = 1.73$

$\frac{221.46}{63.1} = 3.5$

$\frac{131.78}{63.1} = 2.08$

$\frac{249}{63.1} = 3.94$

$\frac{174.64}{63.1} = 2.76$

$\frac{272.07}{63.1} = 4.31$

$\frac{196.55}{63.1} = 3.11$

$\frac{283.04}{63.1} = 4.48$

$\frac{209.75}{63.1} = 3.32$

$\frac{280.74}{63.1} = 4.44$

$\frac{213.8}{63.1} = 3.38$

Fig. 5 Case2)Corner column removal

$\frac{78.32}{63.1} = 1.2$ $\frac{154.49}{63.1} = 2.44$

$\frac{112.9}{63.1} = 1.78$ $\frac{101.52}{63.1} = 1.6$

$\frac{129.74}{63.1} = 2.05$ $\frac{178.78}{63.1} = 2.83$

$\frac{116.69}{63.1} = 1.84$ $\frac{118.64}{63.1} = 1.88$

$\frac{173.26}{63.1} = 2.74$ $\frac{201.32}{63.1} = 3.19$

$\frac{138.65}{63.1} = 2.15$ $\frac{141.81}{63.1} = 2.24$

$\frac{202.23}{63.1} = 3.2$ $\frac{222.59}{63.1} = 3.52$

$\frac{152.27}{63.1} = 2.41$ $\frac{157.46}{63.1} = 2.49$

$\frac{236.61}{63.1} = 3.74$ $\frac{243.26}{63.1} = 3.85$

$\frac{177.63}{63.1} = 2.81$ $\frac{180.56}{63.1} = 2.86$

$\frac{258.46}{63.1} = 4.09$ $\frac{262.96}{63.1} = 4.16$

$\frac{191.03}{63.1} = 3.02$ $\frac{194.39}{63.1} = 3.08$

$\frac{265.02}{63.1} = 4.2$ $\frac{273.69}{63.1} = 4.33$

$\frac{198.59}{63.1} = 3.14$ $\frac{205.89}{63.1} = 3.26$

$\frac{264.1}{63.1} = 4.18$ $\frac{278.93}{63.1} = 4.4$

$\frac{233.62}{63.1} = 3.7$ $\frac{233.62}{63.1} = 3.7$

Fig. 6 Case3)Adjacent to Corner column removal

IV. ADDITION OF BRACING SYSTEM

To check the reliability of bracing system consider same building with bracing system and same column loss scenario is considered for all the cases. Bracing are of size 200 X 200 mm, HYSD 415 and M20. The demand capacity ratios for the same building with bracing system and column loss scenario are as follows.
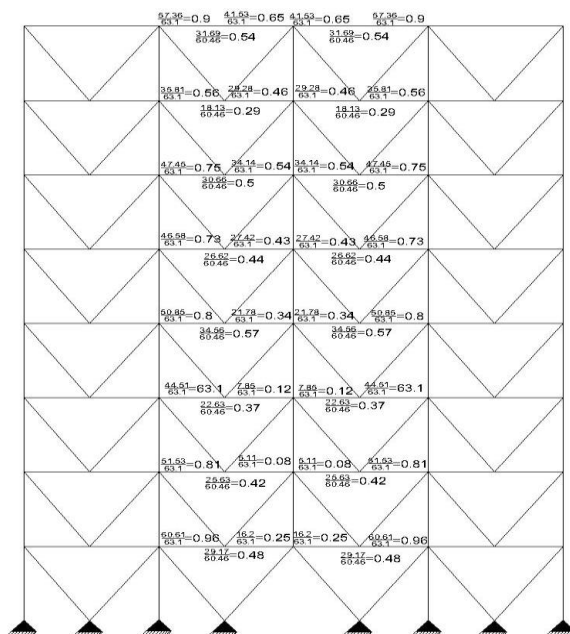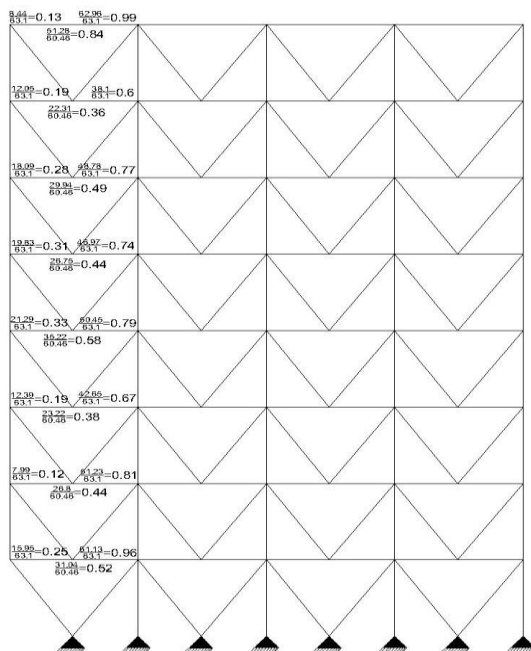
Fig -6: DCR for Case1 with bracing system

Fig -7: DCR for Case2 with bracing system

Fig -8: DCR for Case3 with bracing system

V. CONCLUSIONS

By considering all the cases it is found that when the column in building without bracing system is removed then the demand capacity ratio exceeds 2 which is sign of failure of column according to GSA guidelines but when the column in building with bracing system is removed then the demand capacity ratio is less than 2 which is safe. Hence it can be concluded that the V-type bracing system is reliable to avoid progressive collapse in case of sudden column loss scenario.

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