Progressive Collapse Analysis of Tall Building Subjected To Blast Load

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Abstract : The drastic damage to the property and lives due to the recent terrorist attacks on the infrastructure has led to the need of extensive research on the progressive collapse analysis of multi-storey building subjected to blast loading. Generally, research has been done based on Alternative Path Method (APM) with sudden column removal by ignoring the preferable location of the blast loading. In this thesis, 3D model of high storey steel building with direct simulation of blast load is proposed. Also, the effect of blast loading at various locations has been evaluated. The blast load is analytically determined by the numerical model of structure and compare which was prepared using the SOFTWARE.

***Keywords* –: Tall Structure, Blast, Collapse, Package Bomb, high Storey .**

I. INTRODUCTION

A bomb explosion within or around a building can have catastrophic effects, damaging and destroying internal or external portions of the structures. Bomb damage to structure depends on the type and layout of the structure, material used, range of the located explosive device and the charge weight.

Progressive collapse occurs when an initiating event leads to damage to part of the structure by which this part losses its load bearing capacity. As a consequence the loading pattern of the structure is changed loading to an overloading of other structural element which is thereby also damage. This process continues until the whole structure collapse or a greater part of it.

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1.1 Explosion And Blast Phenomenon

In general an explosion is the result of a very rapid release of large amount of energy within a limited space. Explosion can be categorized on the basis of their nature as physical, nuclear and chemical events.

In physical event: - Energy might be discharged the catastrophic failure of a cylinder of a compressed gas, volcanic ejection or notwithstanding blending of two liquids at different temperature.
In nuclear event: Energy is discharged from the development of different atom by the re generation of the protons and neutrons within the inner acting cores.
In chemical event: The rapid oxidation of the fuel element (carbon and hydrogen atoms) is the main source of energy.

Conventionally, there are many forms of high explosive available and as each explosive has its own detonation characteristics, the properties of each blast wave will be different. TNT is being used as the standard benchmark, where all expressed in terms of an Equivalent charge mass of TNT.

1.2 Blast load effect on structure

When an explosion take place, a thermal chemical reaction occurs in a period of few milliseconds. The explosive material is converted to very hot, dense, high pressure gas. This highly compressed air travelling radially outward from the source at supersonic velocity is called the shock wave front. It expands at very high speed and eventually reaches equilibrium state with the surrounding air. The shock wave also acts in directions that the building may not have been designed for, such as upward pressure on the floor system.

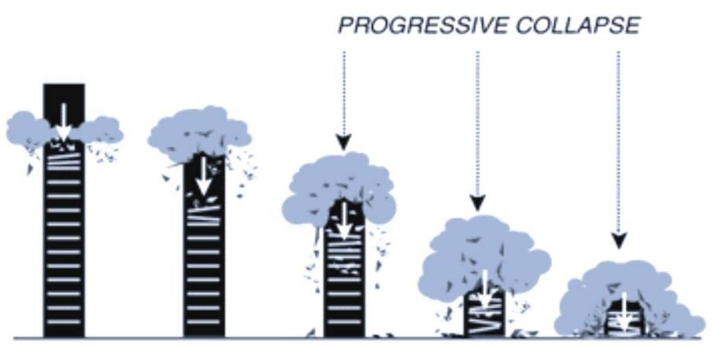


Fig 1. Schematic diagram of progressive collapse chain reaction

1.3 Blast loading

Friedlander's waveform describes a simple blast wave equation and basic equation of the Friedlander waveform describes the pressure of the blast wave as a function of time as

$$P(t) = P_{so}\left(1 - \frac{t - t_a}{t_o}\right) e^{-b\frac{t - t_a}{t_o}}$$

Where, Pso is the peak overpressure,
to is the positive phase duration,
b is a decay coefficient of the waveform and
t is the time elapsed, measured from the instant of blast arrival.

1.4 DCR Criteria

For Linear Static Procedure, GSA has defined Demand-Capacity ratio (DCR), which identifies the magnitude and distribution of potential on both primary and secondary structural elements for quantifying potential Collapse area.

$DCR=QUD/QCE$

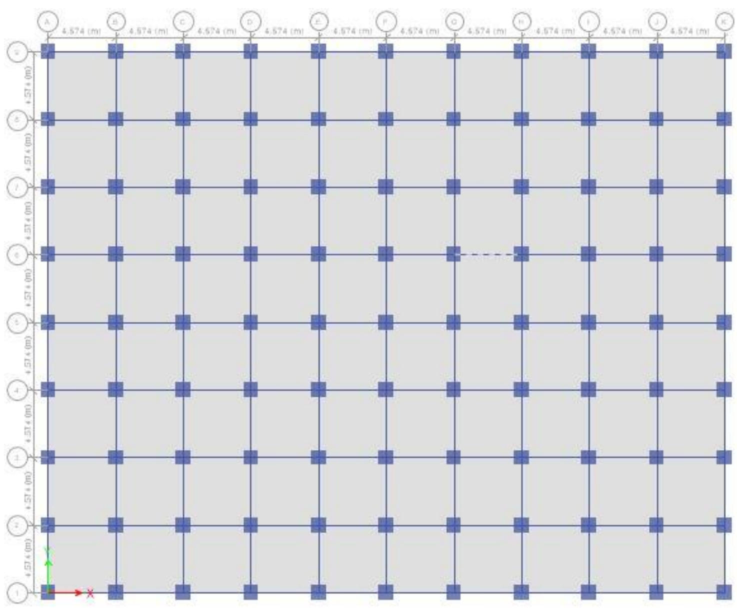
QUD=Acting Force determine in Component
QCE=Expected Ultimate, un-factored capacity of the Component

The allowable DCR values for primary and secondary structural element are:
DCR < 2.0 for typical structural configuration
DCR < 1.5 for atypical structural configuration

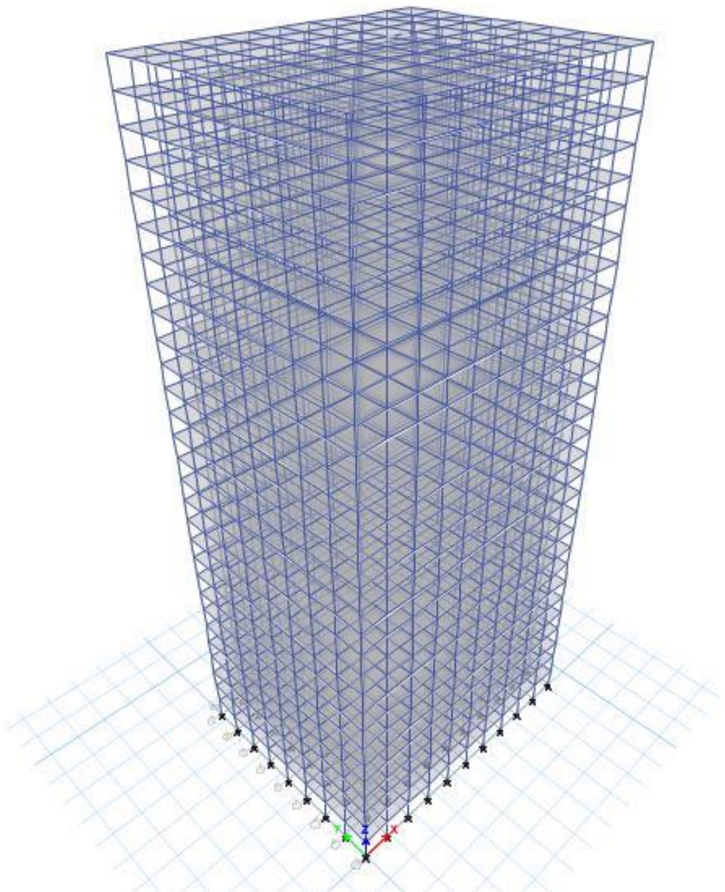
1.5 Details about model

Description	Data
No. of storey	G+29
Bays in x direction	10
Bays in y direcation	8
Bay width	4.574 m both way
Storey Height	3.66 m
Thickness of slab	150mm
Size of beam	450x750 mm
Size of column	1000x1000 mm
Live Load	4 KN/m2

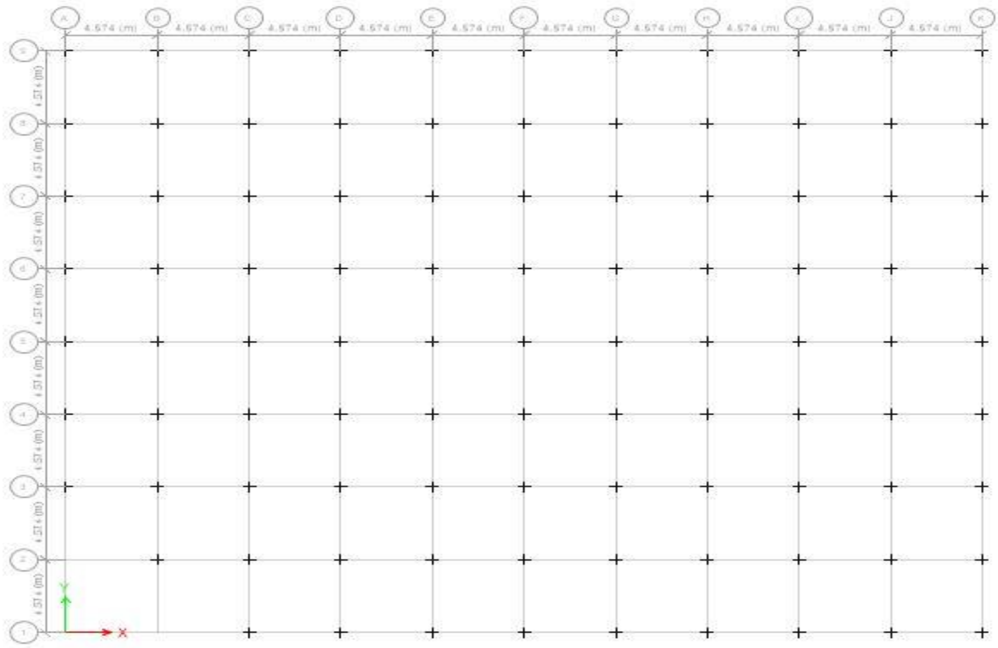
1.6 Plan of model



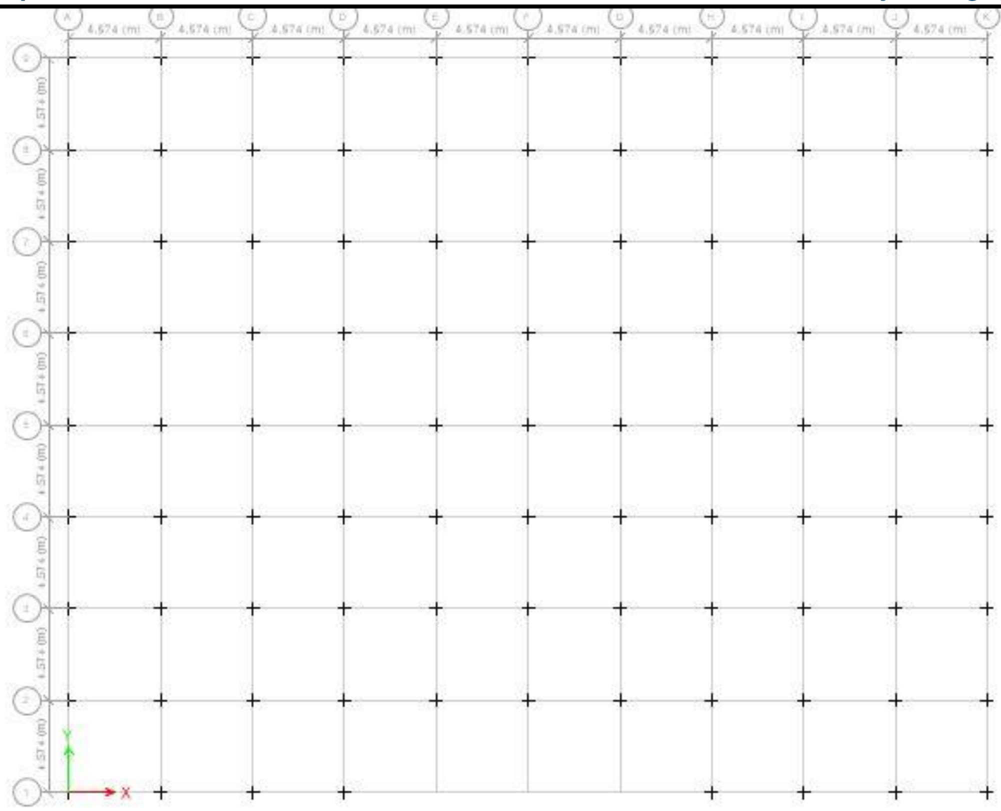
1.7 Elevation of Model



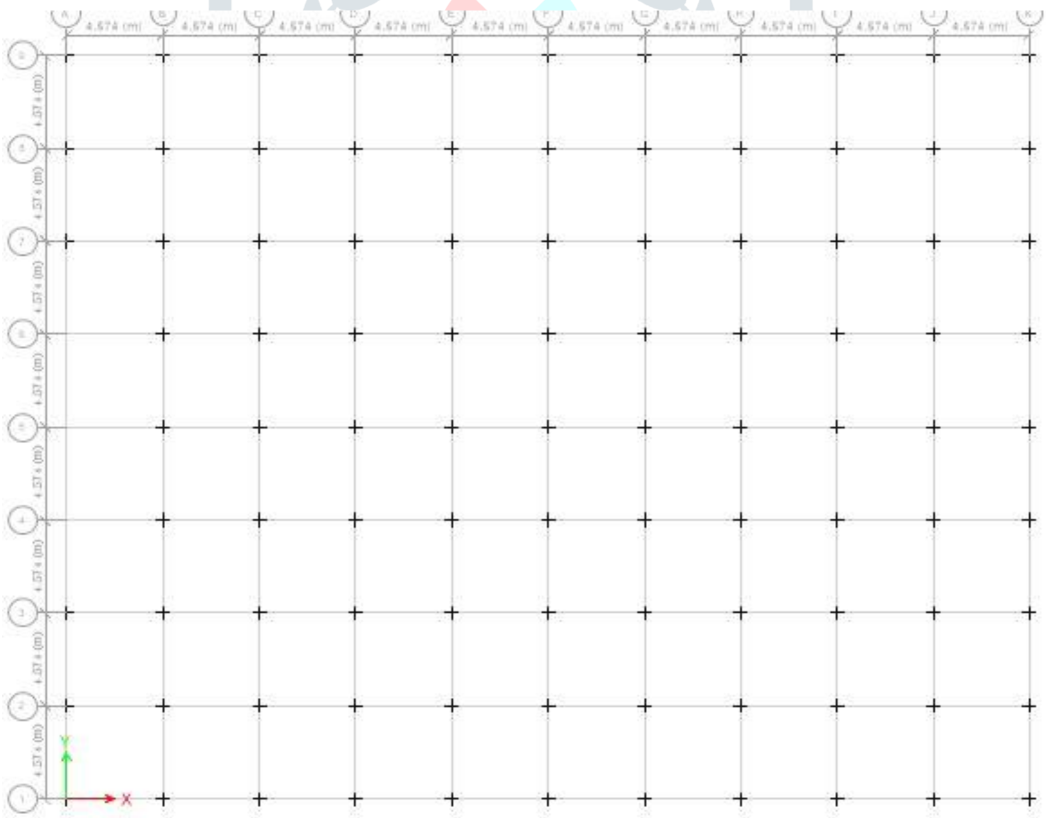
1.8 Cases for Model Analysis



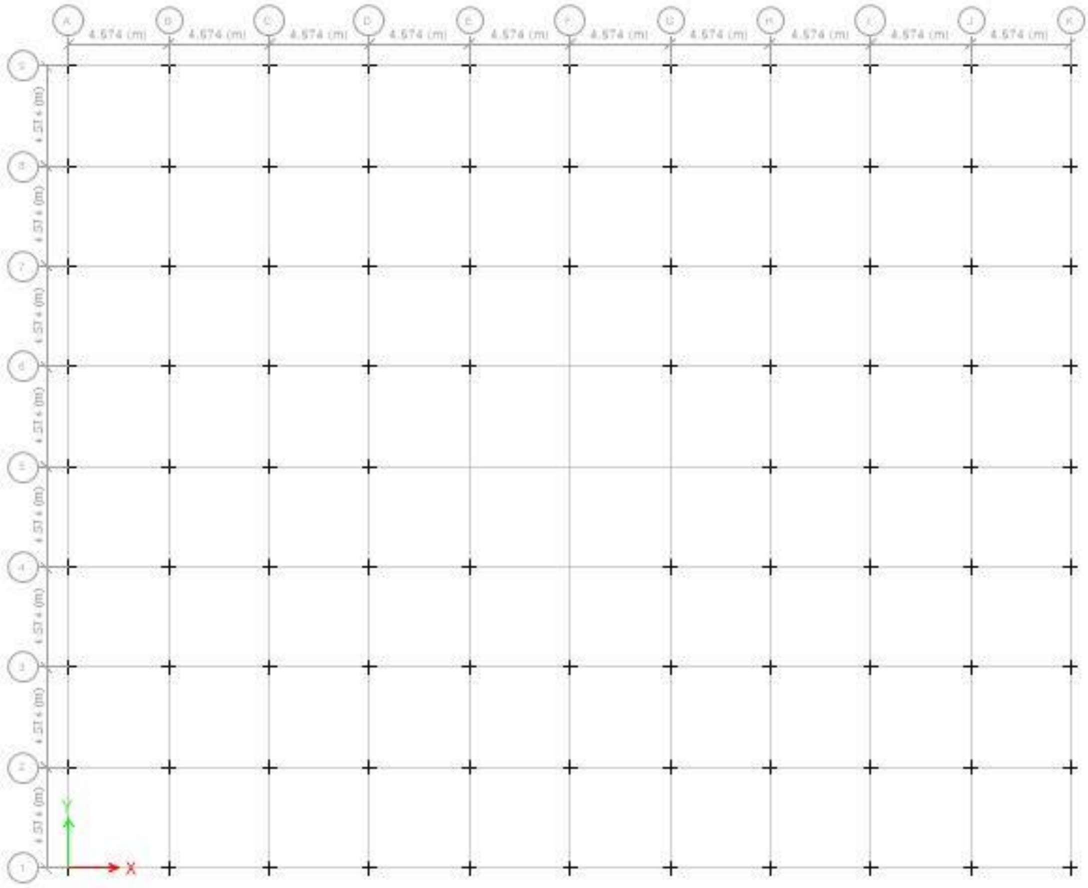
1. Remove a corner columns



2. Remove an External long by columns



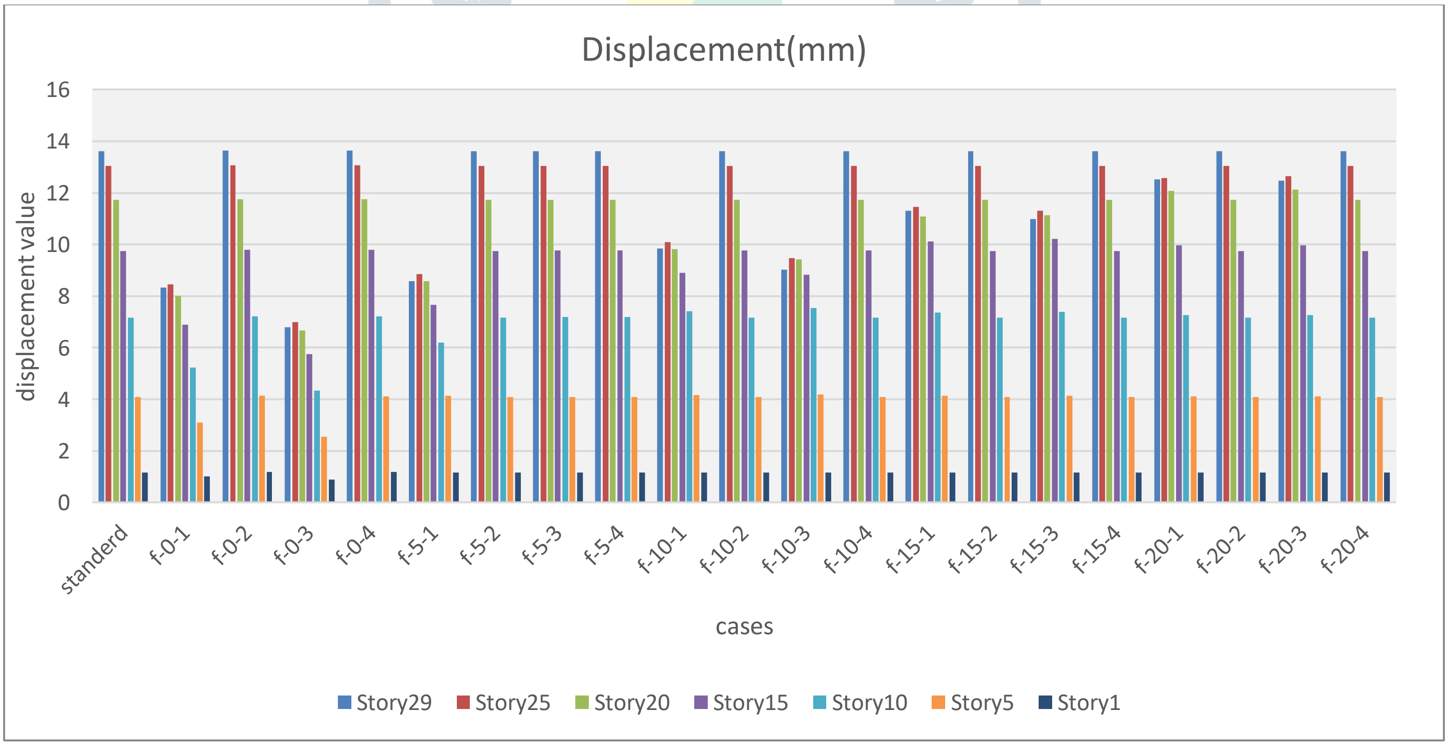
3. Remove an external short by columns



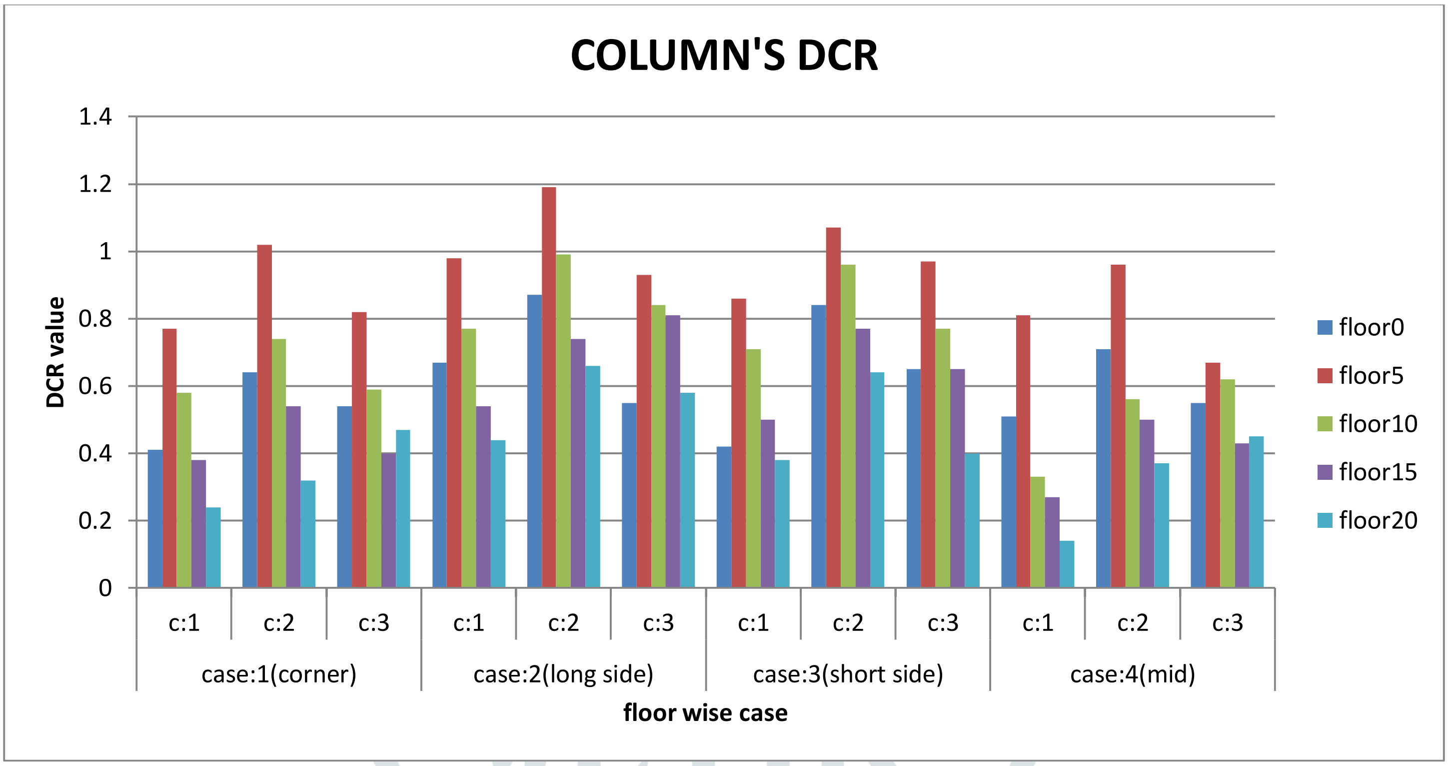
4. Remove interior columns

1.9. Results

A.Comparison of storey displacement in y- direction for different cases with standard case



b. Column's DCR value



1.10 Conclusion

Blast has a characteristic of high amplitude, the result from the displacement and stress results shows that the top storey column are more prone to internal blast effect due to their reduced cross section properties. So, the same cross section properties throughout the all storey should be incorporated.

From the result it can concluded that the internal blast event is not causing collapse of structure due to their small charge weight.

Corner column removal condition 1A is found critical among all the 4 column removal condition. On the other hand, Interior column 3D is having the least DCR values, compared to other removal conditions.

1.11 References

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