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Effect on high rise structure expose to blast load

Rucha N Patel, M.Tech, Structural Engineering, Ganpat University, India. ruchshnm@gmail.com

Prof. Arjun M Butala, Department of Civil Engineering, Ganpat University, India. amb03@ganpatuniversity.ac.in

Abstract: The impression of blast load on building is very important things to consider in a design process. A bomb detonation within structures or straightaway the building can drive damage on the building either in external or internal structural frames, by collapse of walls etc. These kinds of affliction are uncommon and man-made disasters. The impact of blast load is equivalent to a dynamic loads and that demand to take caution while calculating of it. Someone can calculate as other lateral forces like earthquake and wind load. Design fully blast resistant structures is not pragmatic and economic, till the knowledge of mitigating its effect while designing new structures or maintaining old one with its less impact is identical. In this present study, the behavior of G+15 storey RCC structure is analyzed under the blast load with the help of ETAB software. According to the IS code provision, the dead load, live load and wind load has been considered to study the effect of it. Also, the distance of blast and its charge weight is very according to IS 4991-1968.

Keywords —blast resistance building, blast loading, stand-off distance, scale distance, denotation charge weight, dynamic pressure, seismic response.

I. INTRODUCTION

Terrorism is the most dangerous problem the world is facing today. It has caused the feeling of insecurity among the people despite of the advancement in technology. Safety and security being the most important aspects any building, blast resistance of its structure becomes an important concern for safety. The cost will increase as the safety demands are raised; hence it is very important to choose design which is balancing safety and economy. It impossible to design fully blast proof structure, but it can be designed to sustain reasonable blast load. Despite the fact that the magnitude of the explosion and the loads caused by it cannot be anticipated perfectly, efforts can be made to reduce the consequences of the explosion. Standoff distance is decided based on the premises security and location of the building in the premises. Consideration of this load as design load adds cost to the building but increases safety factor. Designer has to choose a design considering balancing between safety and cost. Different designs will have different performance to blast analysis. Different designs will be investigated and modifications in existing designs or new designs will be proposed having better blast resistance. The proposed design will be analyzed and evaluated for different conditions using analysis and design tools.

Blast analysis is the most important things to know the behavior of building during the blast. Blast load is very important to consider as a design load on building. For the better blast resistance structure some study and research do on the blast behavior. So many literatures available for this study they have do different techniques for blast analysis of structure. And also use the different software for blast analysis of the structure.

I chose a malty storey structure and analyzed my structure in ETABS 2013. Define various loads (dead load, live load, earthquake load) in ETABS software. In dead Load, self-weight multiplier is used 1 to calculate dead load as default. Live load or any other define load, the multiplier is zero.

After defining loads and various load combinations the modal analysis is carried out. Brick wall load is assigned on beams. The brick wall of 230mm thickness is considered. The pressure and time for analysis is calculated as per IS 4991:1968 Criteria for Blast Resistant Design OF Structures for Explosions above Ground.

II. BLAST PHENOMENON & EXPLOSIONS

Blast release of energy and hot gases very fast in in milliseconds into the surrounding atmosphere. This explosion caused by the Chemicals (TNT), two chemicals mixing in a high temperature. During blast the hot gases that are generated occupy the space surroundings [1]. Blast load was uniformly distributed load increasing of standoff distance load also decreases. Blasts can be exemplified as physical blast, chemical blast, and nuclear blast. Above the ground surface blast are mainly three different types like air blast, surface blast and high altitude blast. The rapid releasing of energy caused by the wave form of a pressure in the surrounding space is spread as shock front. Due to the

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blast, accumulations of hot gases take place. The absolute maximum pressure over and above the atmospheric pressure take place at the shock wave is known as maximum or peak value of over pressure. Following the shock wave, reduce to around one-half the maximum overpressure and carry through approximately even at the canter of explosion.

A. Blast load and effect on building

Blasts release of energy and hot gases in milliseconds into the surrounding atmosphere. During blast the hot gases that are generated occupy the space surroundings. Blast load was uniformly distributed load. The fig-1 show the vehicle weapon blast with stand-off distance and blast pressure mansion on it [1].

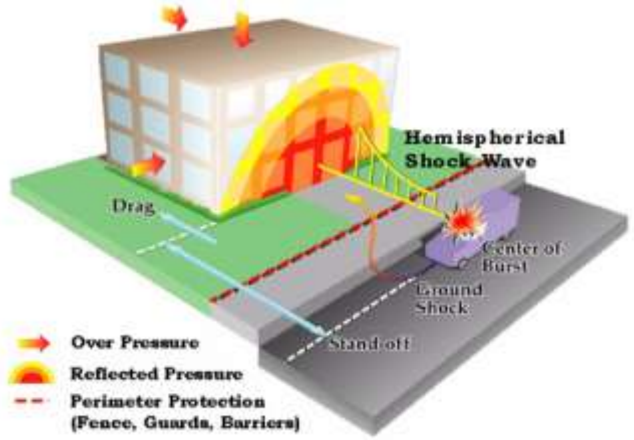

Fig 1: blast load effect on building

It is not possible to declare that blast shall happen in only one direction. Hence safety precautions should be taken from all direction. The highly affected beams and columns because of a blast are that of the basement region. So they are to be strengthened. A feasible way to protect the structure is by providing barrier compound all-round the structure. The process of windows is exterior wall column, lifting up of floors, downward pressure on roof.

B. Blast load profile

An explosion can be defined as a very fast chemical reaction involving a solid, dust or gas, during which a rapid release of hot gases and energy takes place. The phenomenon lasts only some milliseconds and it results in the production of very high Temperatures and pressures.

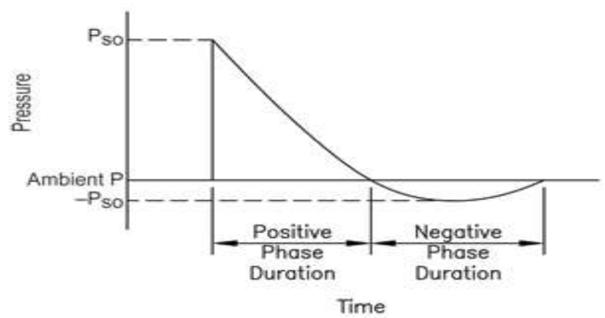

Fig 2: blast wave's pressure

Fig1 shows the idealized profile of the pressure in relation to time for the case of a free air blast wave, which reaches a point at a certain distance from the detonation.The pressure surrounding the element, is initially equal to the ambient pressure Po, and it undergoes an instantaneous increase to a peak pressure Pso at the arrival time tA, when the shock front reaches that point. The time needed for the pressure to reach its peak value is very small and for design purposes it is assumed to be equal to zero [3].

The peak pressure Pso is also known as side-on overpressure or peak overpressure. The value of the peak overpressure and the velocity of propagation of the shock wave decreases with increase in distance from the detonation centre. After its peak value, the pressure decreases with an exponential rate until it reaches the ambient pressure at tA+to, to being called the positive phase duration. After the positive phase of the pressure-time diagram, the pressure becomes smaller (referred to as negative) than the ambient value, and finally returns to it [3].

The negative phase is longer than the positive one, its minimum pressure value is denoted as Pso - and its duration as to. The negative phase of the explosive wave is usually not taken into account for design purposes as it has been verified that the main structural damage is connected to the positive phase. Additionally, the pressures that are produced from the negative has of the blast wave are relatively small compared to those of the positive phase and since these are in the opposite direction, it is usually on the safe side to assume that they do not have a big impact on the structural integrity of buildings under blast loads[6].

The damage in a building depends on the energy imparted to it through the reflected shock front of explosion, which is contributed by both the positive and negative phases of the pressure-time history. The pressure and hence forces on the building vary in time and space over the exposed surface of the building, depending on the location of the detonation in relation to the building. Therefore, when studying the response of a structure under a specific blast, the location of detonation which produces the most severe effects on the structure should be identified.

III. MODELING AND ANALYSIS

In this study, I considered 15 story building. The building is model in ETABS software. Dimension of building 27.5m x20m with 5bays in X direction 5.5 meters and 5 bays in Y Direction 4 meters respectively. Total height of building is 45.5m, Floor height 3m.

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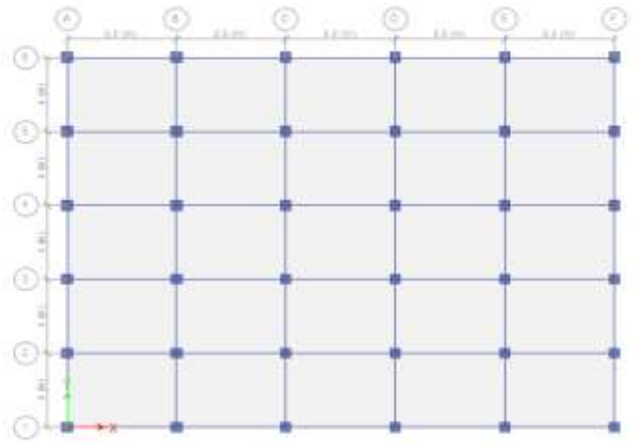

Fig 3: building plan

A. Different cases for analysis

Case: 1 blast of 200 kg (TNT) explosive with stand -off distance 21m

TYPE 1 model – conventional frame structure.

TYPE 2 model – conventional frame structure with increase beam and column size.

TYPE 3 model – convention frame with adding the shear wall at corner and center.

Case: 2 blast of 500 kg (TNT) explosive with stand -off distance 30m

TYPE 1 model – conventional frame structure.

TYPE 2 model – conventional frame structure with increase beam and column size.

TYPE 3 model – convention frame with adding the shear wall at corner and center.

Table 1: beam and column size for different model

	Standoff dist	Blast load	Type of model	Column size (mm)	Beam size (mm)
Case1	21	200	1and 3	500x500	400x500
			2	1000x1000	1000x900
Case2	30	500	1 and3	500x500	400x500
			2	1000x1000	1000x900

Thickness of wall is 230mm.
Thickness of the slab is 150mm.
Thickness of the shear wall is 200m.
Unite weight of concrete 25 KN/m^2.
Grade of concrete is M35.

Table 2: Earthquake parameter

details	Value
R	3
I	1.5
Z	0.16
Sa/g	3

Where,
Z= zone factor
Sa/g= soil type iii
R= response reduction factor
I= importance factor

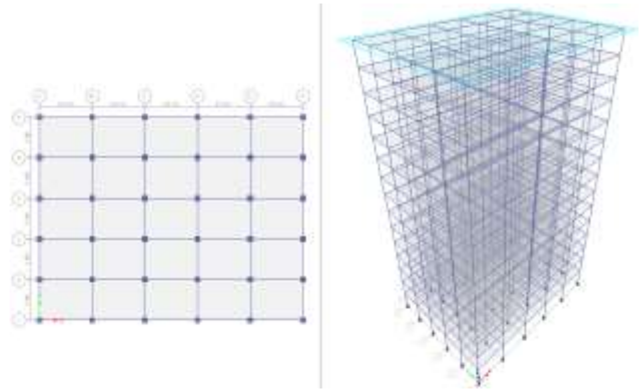

Fig 4: type 1 model

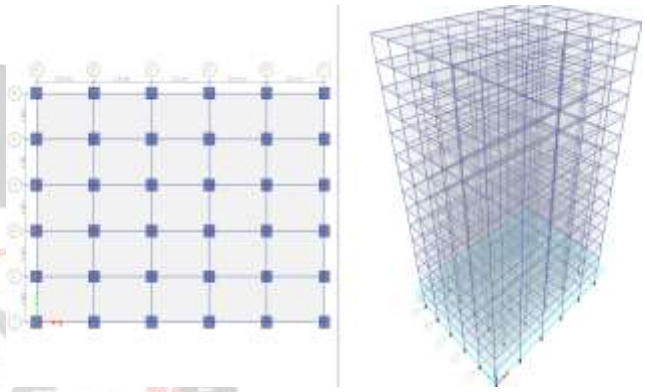

Fig 5: type 2 model

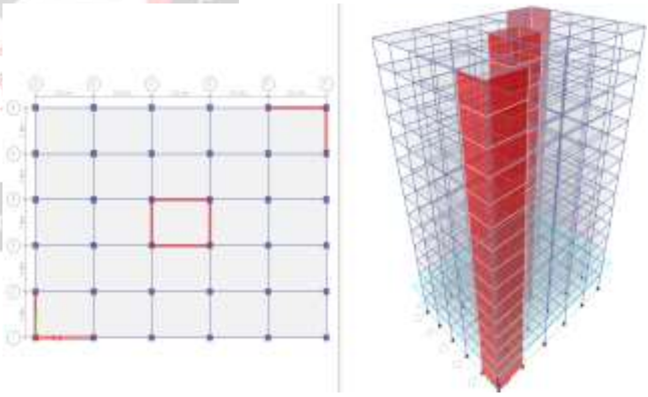

Fig 6: type 3 model

B. Static load

Dead load, live load and earthquake load consider in the all model.

i. **Deal load:** This load is considered from IS -875 part-1-1987. Dead load includes the self-weight.

ii. **Live load:** this load is obtained from code IS-875-1987 (PART 2) table 1. 4.0kN/m^2 is assumed as the UDL on the building.

iii. **Earthquake load:** As per code IS 875-1987 part2 from Table1. The structure is assumed to be in

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Zone-II. As per Table 2 of IS 1893 – 2002 zone factor is considered. 5% damping is assumed, 1.5 as importance factor considered from table 6 of IS 1893-2002.

Response reduction factor R is considered as 3 in this case. Soil type III, Importance factor is 1.

C. Load combination:

This load combination is use in the analysis.

5DL+1.5WL
1.5DL+1.5WL-1.5EQY
0.9DL+0.9WL+1.5EQX
0.9DL+0.9WL-1.5EQX
0.9DL+0.9EL+1.5EQY
0.9DL+0.9WL-1.5EQY
1.5DL+1.5LL+1.5WL
1.2DL+1.2LL+1.2WL+1.2EQX
1.2DL+1.2LL+1.2WL-1.2EQX
1.2DL+1.2LL+1.2WL+1.2EQY
1.2DL+1.2LL+1.2WL-1.2EQY
1.5DL+1.5WL+1.5EQX
1.5DL+1.5WL-1.5EQX
1.5DL+1.5WL+1.5EQY

Table 3: Blast load calculation

characteristics of blast	Case 1	Case 2
scale distance (x) (m)	42	60
air pressure (pa)	1	1
pressure		
pso	0.76	0.4
pro	1.97	0.93
qo	0.186	0.054
scale time (to)	1.28	1.16
td	10.1	13.3
M	1.285079208	1.158817131
a	344	344
U=M*a	442.0672476	398.633093
pressure on the building		
height (m)	45.5	45.5
B	27.5	27.5
L	20	20
S=H or B/2		
s=H	45.5	45.5
B/2	13.75	13.75
whichever is less (s)	13.75	13.75
tc	93.31159506	103.4786141
Tt	45.24198548	50.17144926
tr	124.4154601	137.9714855
tr>td no pre. On backface		
side face		
Cd	-0.4	-0.4
pso+cd*qo	0.6856	0.3784
convert to kn/m^2		
pro	19.3257	9.1233
Pro (KN/m^2)	193.257	91.233
side face pressure	6.725736	3.712104
(KN/m^2)	67.25736	37.12104

IV. RESULT AND DISCUSSION

Case: 1 blast of 200 kg (TNT) explosive with stand -off distance 21m.

A. Displacement (mm)

Earthquake in X- direction.

Table 4: Displacement vs Storey Level (X-Direction)

storey	Model-ty1	Model-ty2	Model-ty3
15	37.97	9.87	15.39
14	37.1	9.62	14.3
13	35.8	9.28	13.15
12	34.12	8.86	11.96
11	32.03	8.36	10.73
10	29.6	7.8	9.48
9	27	7.2	8.22
8	24.1	6.56	6.97
7	21.2	5.9	5.74
6	18.17	5.22	4.57
5	15	4.54	3.46
4	11.9	3.86	2.45
3	8.7	3.18	1.57
2	5.65	2.5	0.85
1	2.63	1.71	0.32
Base	0	0	0

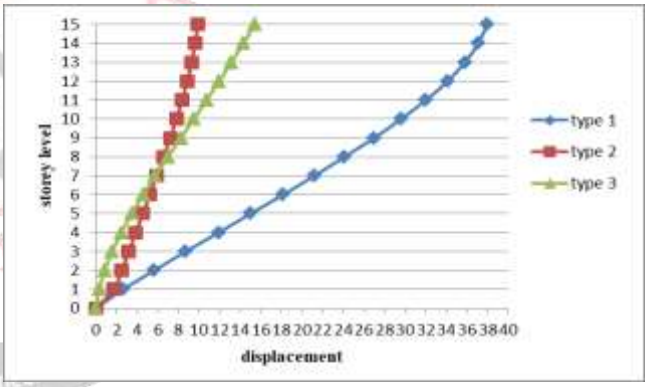

Fig 7: displacement vs storey level (x- direction)

As we can see in the above values the displacement gradually decreases as the storey level decreases showing zero at ground floor. When the displacement is compared with three different models it is seen when increase the beam and column size and provide the shear wall displacement is decrease. Displacements are less in model-ty 3 when compared to model-ty 2. The graph is then plotted displacement (mm) with respect to storey level.

Earthquake in Y- direction.

Table 5: Displacement vs Storey Level (Y-Direction)

storey	Model-ty1	Model-ty2	Model ty3
15	33.91	9.75	18.41
14	30	9.42	17.22
13	31	9.01	15.9
12	30	8.54	14.6
11	28.1	8	13.22
10	25.9	7.41	11.7

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9	23.5	6.79	10.2
8	21	6.14	8.8
7	18.4	5.48	7.31
6	15.7	4.82	5.86
5	13	4.15	4.48
4	10.3	3.15	3.21
3	7.61	2.87	2.08
2	4.95	2.25	1.13
1	2.38	1.57	0.43
base	0	0	0

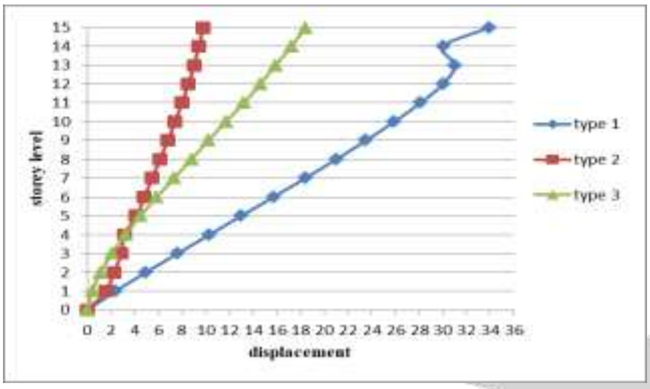

Fig 8: displacement vs storey level (y- direction)

As we can see in the above values the displacement gradually decreases as the storey level decreases showing zero at ground floor. When the displacement is compared with three different models it is seen when increase the beam and column size and provide the shear wall displacement is decrease. Displacements are less in model-ty 3 when compared to model-ty 2. The graph is then plotted displacement (mm) with respect to storey level.

B. Storey drift

Earthquake in X- direction.

Fig. 9 represents the storey drifts vs storey level in y-direction. The storey drift is observed to be less in type 3 model compare to other models.

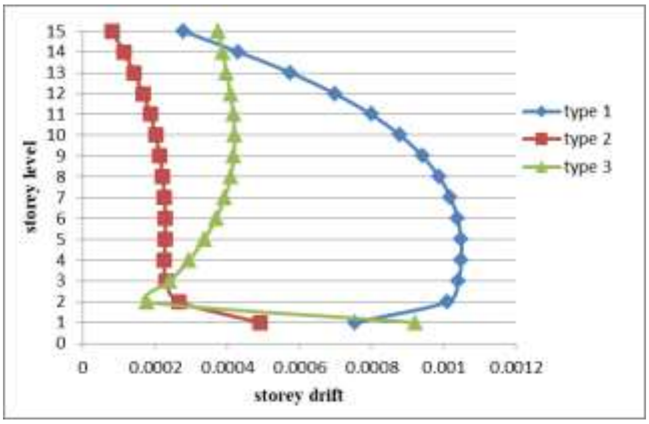

Fig 9: storey drifts vs storey level (x- direction)

Earthquake in Y- direction.

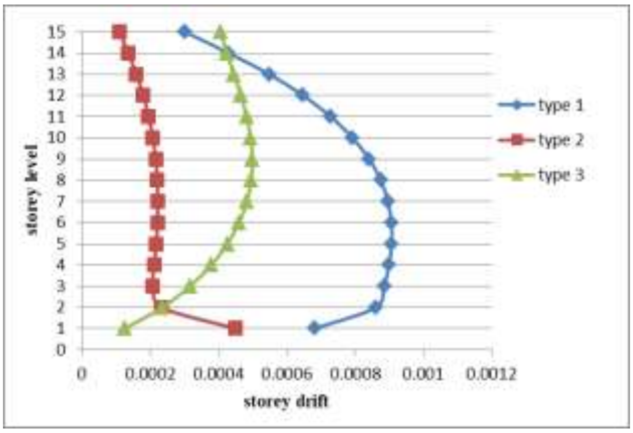

Fig 10: storey drifts vs storey level (y- direction)

As we can see in the above values the storey drift are compared with different models, for earthquake in both X and Y directions the storey drift is more in type 1 and less in type 2. When the 2 and 3 models are compared the storey drift are less in model 3.

C. Storey shear (KN)

Table 6: storey level vs Storey Level

storey	Model-ty1	Model-ty2	Model-ty3
15	322.1174	747.8201	349.3551
14	625.3685	1495.3364	697.9371
13	883.7601	2132.2733	994.9537
12	1100.881	2667.4773	1244.53
11	1280.319	3109.7946	1450.792
10	1425.665	3468.0716	1617.864
9	1540.505	3751.1547	1749.871
8	1628.43	3967.8902	1850.939
7	1693.028	4127.1244	1925.193
6	1737.888	4237.7038	1976.759
5	1766.598	4308.4745	2009.761
4	1782.747	4348.2831	2028.324
3	1789.925	4365.9758	2036.575
2	1791.719	4370.399	2038.637
1	1791.719	4370.399	2038.637
base	0	0	0

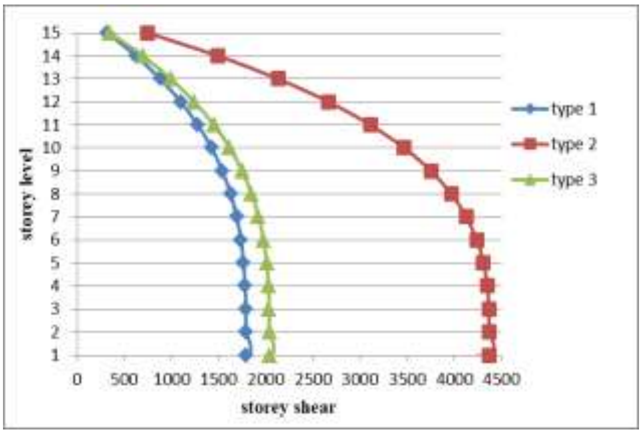

Fig 11: storey shear vs storey level

As we can see in the above values the storey shear which are compared with different models, for storey shear is more

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in type 2 and less in type 3. When the 2 and 3type models are compared the storey shear is less in model 3 which is due to the provision of shear walls.

Case: 2 blast of 500 kg (TNT) explosive with stand -off distance 30m

A. Displacement

Analysis of tall building for blast 500 kg (TNT) explosive with stand -off distance 30m has given an idea how to behave a building the earthquake and blast is happen. It is seen that the response of building in x and y direction is reduced with increase the beam and column size. When shear wall provide they give more desirable result then increase the beam column size.

B. Storey drift

The storey drift is less in type 3 model compare to other models.

V. CONCLUSION

After completing the present work on analysis of structure subjected to blast effect the flowing conclusion have been made. Important building like embassies, banks, hospital, monumental building, headquarters, historical building, government building, federal building etc. should be designed and analyzed to withstand blast effect within acceptable limits. After analyzed the structure know the top storey have large displacement when compared to bottom storey. As the height of building increase then increase the storey displacement. By increasing beam and column size in structure will improve the blast resistance but it is not practical way to for every situation because huge cross section of beam and column needed to resist blast load. Addition of shear wall gives better blast resistance they give more desirable result and it is economical too compared to other models.

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