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Simulation of Building Demolition using ANSYS

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Abstract: Demolition of any structure is a ground to earth technique which means destroying down or falling down of a building with the help of equipment, machineries, explosives or with manual techniques without affecting the surrounding. Demolition with explosives known as implosion weakens or removes critical supports so that the building can no longer withstand the force of gravity and falls under its own weight. Once the central support is destroyed and the surrounding columns are weakened, due to gravity the entire mass will come down on its footprint. Test blast on columns helps to determine the charge weights for effective explosion. It also helps to ensure the efficiency of explosives and detonators used. In this study, explosives were placed at different locations with charge weight obtained after conducting test blast. The building was analysed using ANSYS AUTODYN and the response of the building was captured for two different explosives namely, TNT and C4. After the analysis the results were compared with the experimental result obtained by conducting rebound hammer test on concrete. After comparison, both the explosives were found to be safer for demolition process and C4 explosive was found more effective than TNT explosive for demolition process.
Keywords: Demolition, Explosives, Implosion, Test blast, ANSYS AUTODYN, TNT, C4

I. INTRODUCTION

Demolition of any structure is the process of destroying down or collapsing down of large buildings after its useful life period with the help of some equipment or other method with a legal procedure followed by the consent of the local authority. Demolition method applied in a structure depends on various factors such as site condition, type of structure, age of building, economy and most important, its location with presence of its surrounding with the structural stability. Explosive demolition is the preferred method for safely and efficiently demolishing large structures. When everything is planned and executed correctly, the total damage of the explosives and falling building material is sufficient to collapse the structure entirely. The main procedure for the demolition process includes the preparation of stability reports, pre blast considerations for the weakening of structural elements, wrapping holes with gunny bags after placing the explosive, ballasting of charge and the falling of the structure on its footprint.

The realistic and efficient simulation of a demolition of a structure by means of controlled explosives requires a powerful simulation model that covers the entire complex dynamic process that is evoked by the ignition of the loads and ends with the collapse of the building. To avoid the damage of the neighbouring building or traffic facilities, an accurate prediction of building collapse is needed. Otherwise uncontrolled collapse may cause great physical major collateral damage. In modern construction industry, with more importance being given to renovation and rehabilitation projects, demolition has become an inevitable part. Thus implosion and silent demolition techniques have proved to be the most efficient methods in terms of cost and time. In the light of increasing concerns for eco-friendly and sustainable development, the reuse of demolition wastes for construction purposes can prove to be better alternative for demolition waste management. Using finite element analysis model, we can control the unwanted collapse of building thereby saving time and cost.

Implosion technique employs explosive which can be defined as substance or a mixture of substances susceptible to rapid changes with an extremely short time frame during which a large volume of gas is produced and energy is released, usually in the form of heat. Explosion occurs due to the action of a stimulus, known as initiation, which is generally small and can be achieved through percussion, shock, friction, heat or sympathy explosion. Device called detonator is used for this initiation, and via a primary explosive charge, a chemical chain reaction leads to a secondary explosion, which inturn detonates the explosive charge. It can be electric or non-electric. After placement, the charges re-detonated through an initiation system. The explosives present in vertical elements detonate, causing a structural vacuum within which through gravity the structure collapse, fragmenting due to its own weight, enabling easier access to debris which can then be taken apart using traditional methods.

In a building the main load bearing elements are columns, beams and load bearing walls. The load transfer takes place mainly by columns and if this load path is disturbed, it results in the overall fall of the structure. Demolition process using explosive is based on this principle. So for demolition blasters load explosive on columns.

In this study two explosives are considered, TNT and C4. The criteria for the selection of explosive is that the maximum principal stress developed in the immediate vicinity of the explosive should be greater than the compressive strength of concrete. For finding the maximum principal stress, finite element analysis can be done using ANSYS AUTODYN software. Compressive strength of concrete is found using rebound hammer test. Rebound hammer test is a non-destructive test by which the strength of concrete can be found out without destroying the structure.

Trinitrotoluene (TNT) is a chemical compound which is best known as an explosive material with convenient handling properties. The explosive yield of TNT is considered to be the standard measure of bombs and other explosives. It has a detonation velocity of 6940 m/s and density of 1.63 g/cm^3. C4 or composition C4 is a common variety of the plastic explosive family known as composition C. C4 is composed of explosives, plastic binder, plasticizer to make it malleable and usually a marker or odorizing taggant chemical. C4 is stable and an explosion can only be initiated by a shock wave from a detonator. C4 is very stable and insensitive to most of the physical shocks. It does not explode when set on fire or exposed to microwave radiation. Detonation can only be initiated by a shockwave, such as when a detonator is inserted into it. C4 has a detonation velocity of 8040 m/s and density of 1.6 g/cm^3.

II. NEED FOR THE STUDY

Accidental blasting projects have shown that demolition using explosive is error prone as it is difficult to determine the type of explosive, its optimal amount and position of explosives. Due to their cost and time efficiency, demolition methods employing controlled explosives requires much attention. So in order to safely and successfully perform demolition, it is essential to determine the appropriate explosive and its placement within the structure. In this study different explosives are compared and the locations of placement for these explosives for effective explosion are found out.

III. SCOPE AND OBJECTIVES

The scope of this study is to analyse RC building subjected to explosions during demolition using ANSYS software. Further to determine the best suitable explosive, its charge weight and the suitable location of its placement within the structure. The blast analysis of the structure is carried out with following objectives:

A. To conduct finite element analysis for different explosives within the building.
B. To conduct experimental testing on concrete to find its compressive strength.
C. To estimate the charge weight of explosive.
D. To suggest the best explosive ad optimum placement within the structure.

IV. METHODOLOGY

In this study, a two storeyed RC building is considered for analysis. Experimental testing of concrete is done on concrete to find the compressive strength of concrete. For this rebound hammer test is done. The result obtained from experimental testing is compared with the FEA result. For conducting the experiment, a cube of standard size, 150 mm x 150 mm x 150 mm of grade M35 is casted and the compressive strength is obtained using rebound hammer after 28 days. The compressive strength of concrete thus obtained is compared with the analysis result. Two steps for analysis are:

A. Test blast
B. Analysis of building

For test blast, explosives are kept on columns as they are the main path for load transfer. Test blast helps to determine the optimum amount of explosive which thereby avoids the underloading or overloading of explosives. After determining the optimum amount of explosive, the location for placement of explosive is chosen. The selected position should be such that it helps in the inward fall of the structure. After determining the locations, analysis of building is performed using the two explosives, TNT and C4. The analysis results are then compared with the experimental results.

The two storey building subjected to the study has six columns in a storey of two different dimensions. M35 concrete is used for analysis. Details of building elements are given in Table 1.

The model of RC building is shown in Fig. 1. For determining the charge of explosives, trials are done by placing different amounts of explosive at the centre of the column. From the material status and damage contour, the charge of explosive can be determined. The geometry of the two columns are shown in Fig. 2 and Fig. 3.

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Table 1 Details of building elements

Component	Dimension
Column 1	600 mm x 300 mm
Column 2	300 mm x 300 mm
Beam	500 mm x 300 mm
Storey height	3750 mm
Wall thickness	150 mm

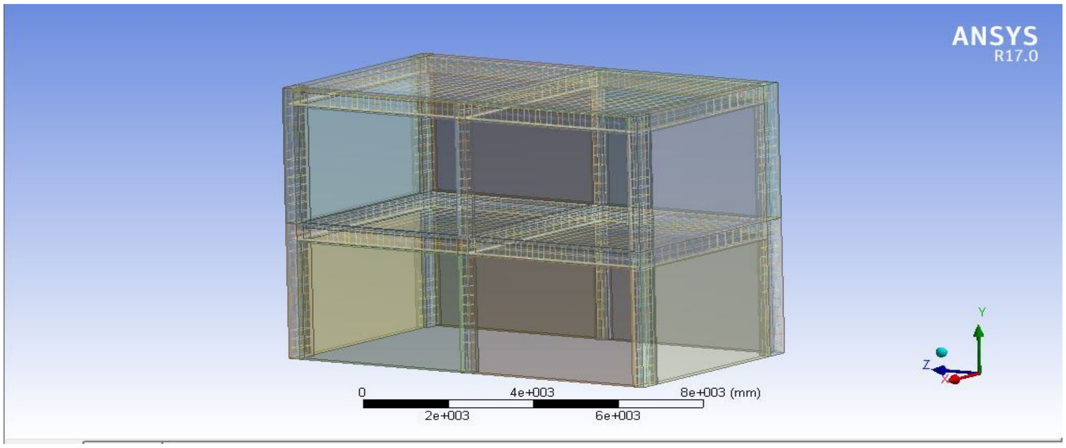

Fig. 1 Model of two storeyed RC building

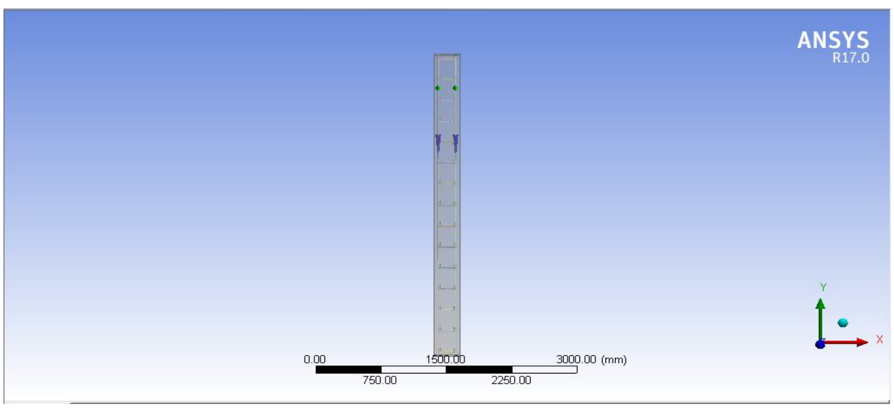

Fig. 2 Geometry of 300 mm x 300 mm column

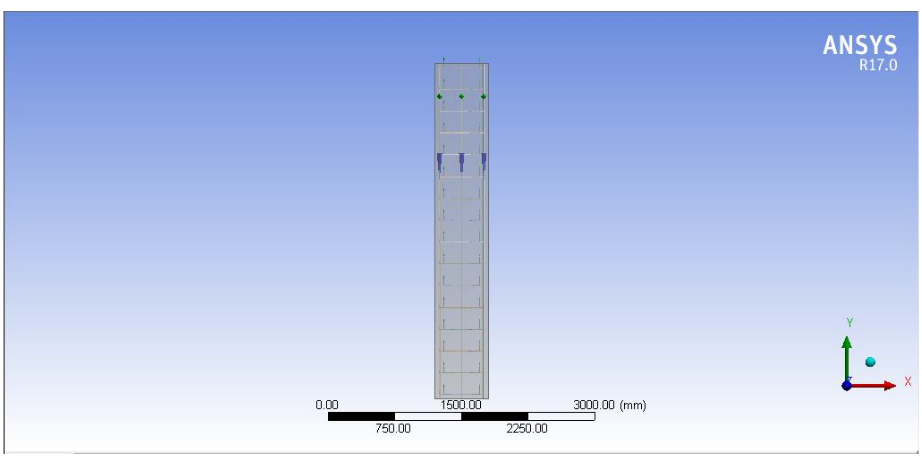

Fig. 3 Geometry of 600 mm x 300 mm column

Blasters perform test blast on columns by varying amounts of explosive material and based on the effectiveness of each explosion, they determine the minimum charge needed to demolish the columns. The cross sectional dimensions of the column, its compressive strength, its condition, and reinforcement details are all variables which affect the column charge quantity and type of explosive required. Test blast trials are done on both the columns with the two explosives. The initial charge weight is obtained from the literatures referred and the rest of the charges are taken randomly.

Table 2 Different charge weight cases considered for test blast

Column	Explosive	Charge weight(kg)
600 mm x 300 mm	TNT	150 175 185 200
	C4	100 125 135
300 mm x 300 mm	TNT	70 100 150
	C4	50 75 100

V. RESULTS AND DISCUSSION

The criteria for the selection of explosive for demolition is that, the maximum compressive stress developed in the immediate vicinity of explosive should be greater than the compressive strength of concrete. The FEA results after the analysis of building are compared with the experimental results. Test blast trials give effective charge weight for each of the column for the two explosives. Explosives are kept at locations which causes the easy fall of the structure on its footprint.

A. Test Blast

After conducting test blast with different test charges, the effective charge is chosen for demolition process. Effective charge is the charge weight of explosive which corresponds to the complete damage of column. Table 3 shows the effective charge weights for each column with the two explosives.

Table 3 Charge weights for explosion of columns

Column	Explosive	Charge weights(kg)
600 mm x 300 mm	TNT	185
	C4	135
300 mm x 300 mm	TNT	100
	C4	75

B. Location of placement of explosive

The location of placement of explosive is selected such that it helps in the easy inward fall of the structure. The explosive are placed on the outer face of columns so that on explosion, it breaks and fall inwards. This location of explosive cause the fall of the structure on its footprint. If the explosives are placed on the inner faces, on explosion, the column breaks in the outward direction which may cause the flying of debris and damage to the surrounding buildings. So all explosives are placed on the outer faces of columns. Fig. 4 shows the location of explosive on the column.

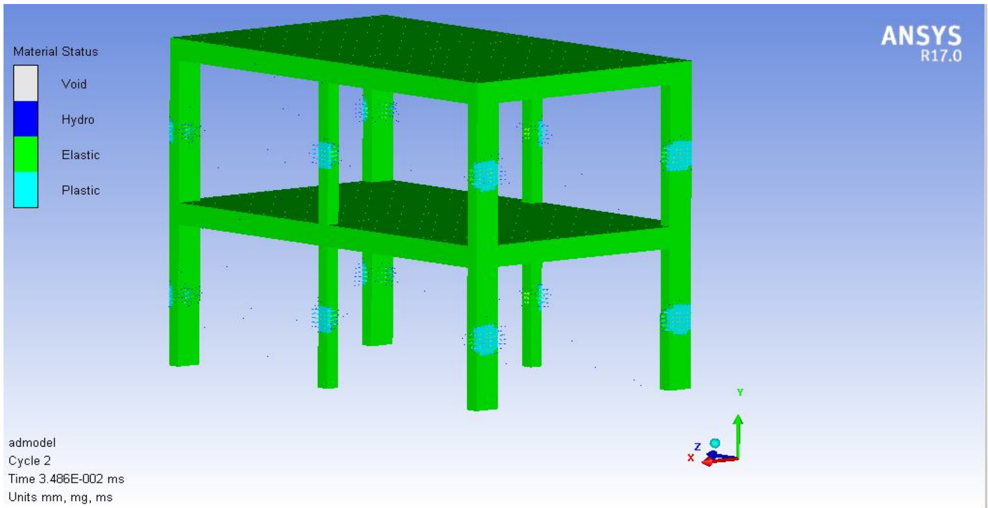

Fig. 4 Location of placement of explosive

C. Analysis of building

The building is analysed using the two explosives, TNT and C4. The finite element analysis (FEA) results are compared with the experimental result. Fig. 5 shows the comparison of experimental result with the FEA results. The experimental test value obtained is 44 MPa. From the comparison chart it can be seen that both the compressive strength values obtained after finite element analysis are greater than the experimental value. From this it can be inferred that both the explosives are suitable for demolition process. Among the two explosives, C4 has greater value than TNT. So C4 is more powerful than TNT for demolition process.

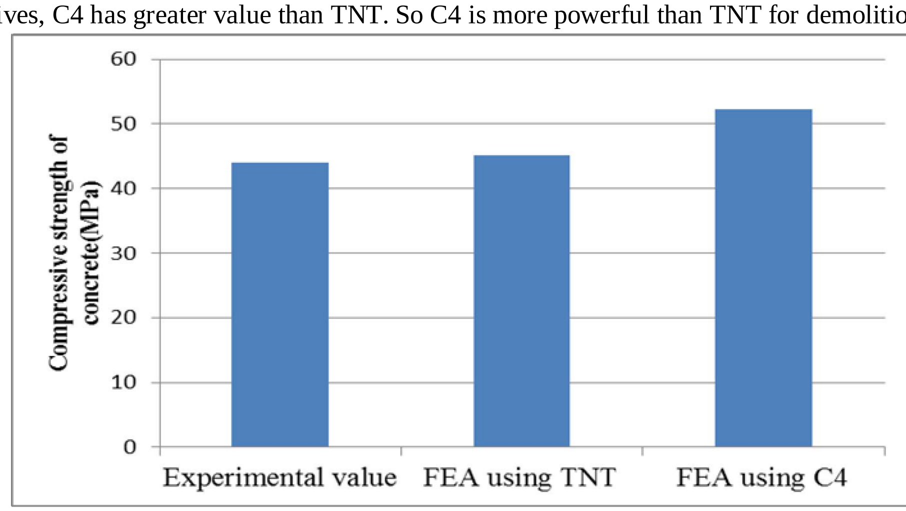

Fig. 5 Comparion of results

VI. CONCLUSIONS

The analysis of structural failure of RC frame building caused by the blast load during demolition was studied using two explosives, TNT and C4. Test blast was performed on columns as they are the main load transferring path in a building. The effects of different charge weights on columns were studied. For heavy explosive charge full damage was obtained. Experimental test was carried out to determine the compressive stress in concrete. After analysis following conclusions were made:

A. Test blast was done on 600 mm x 300 mm column to determine the optimum charge weights and 185 kg of TNT and 135 kg of C4 was found suitable for effective demolition.

B. Test blast was done on 300 mm x 300 mm column to determine the optimum charge weights of explosive and 100 kg of TNT and 75 kg of C4 was found suitable for effective demolition.

C. Experimental testing was conducted on concrete to find its compressive strength. Rebound hammer test was done to find the value.

D. The maximum compressive stress generated due to TNT and C4 explosive after FEA analysis was found more than the compressive strength of concrete found by experimental method. Hence both the explosives will implode the building safely.

E. After finite element analysis for the explosives TNT and C4 for the two storeyed reinforced cement concrete structure, it is observed that C4 explosive is more suitable for the implosion of the building as it generated greater principal stress value than TNT.

VII. SCOPE FOR FUTURE WORK

A. Further studies can be done by considering other types of explosives for demolition of buildings.

B. By varying the location of explosive within the structure, more ways of inward fall of the structure can be studied.

C. As demolition is an error prone method, more safer and economical ways of falling of the structure are needed to be studied.

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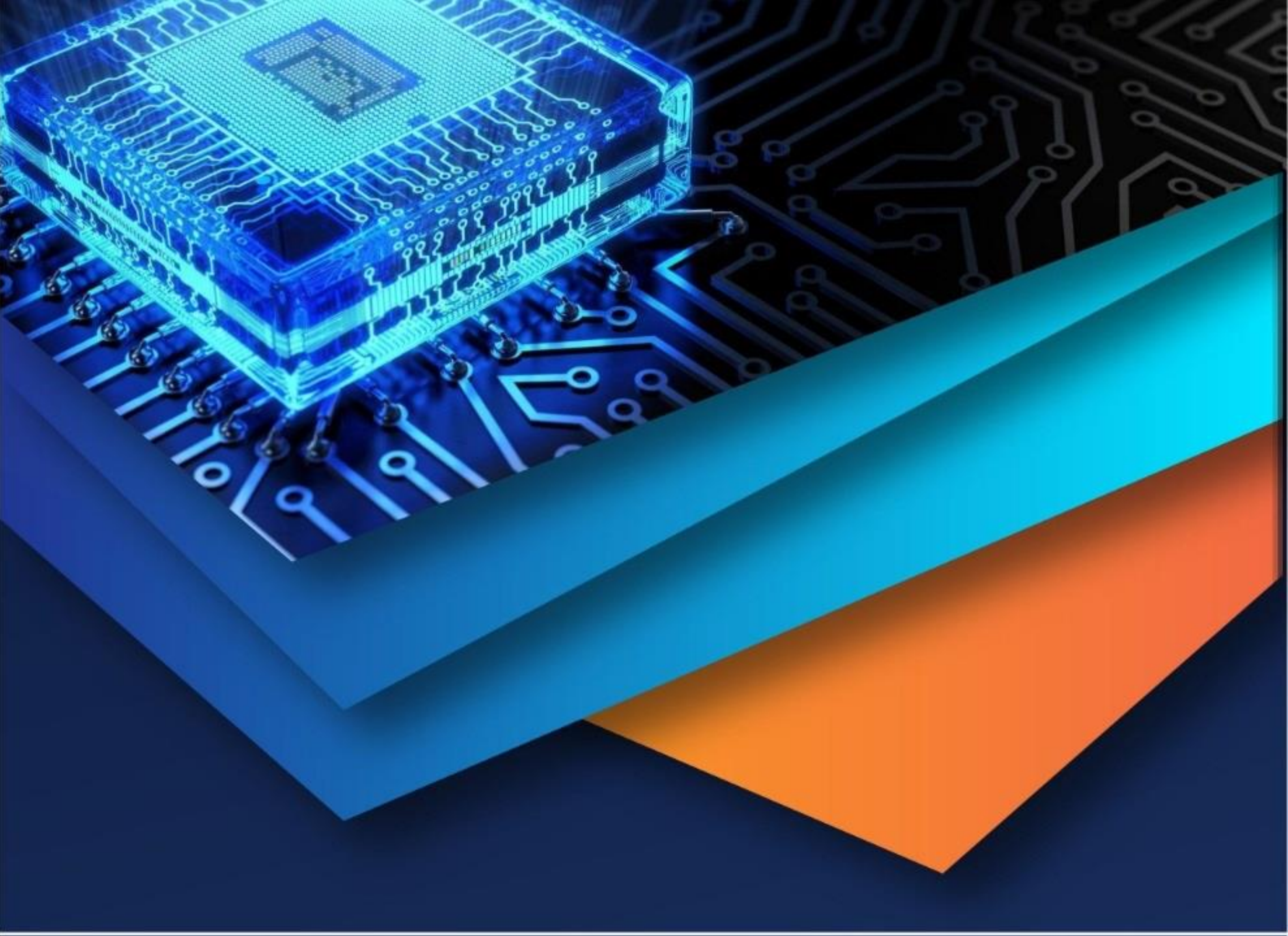

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