Demolition of Structure using Implosion Technology and Reuse Waste- a case study

Poonam kotulkar[1], Trupti Kshirsagar[2], Aditi Vibhute[3]
[1, 2, 3] Department of Construction Managment
[1, 2, 3] Dr. D. Y. Patil Institute of Engineering, Management and Research, Pune

Abstract-*Demolition method applied in a structure depends upon various factors such as site condition, type of structures, age of building, height of building and economy and most important its location with presence of its surrounding with its structural stability. For small buildings, it is a simple process with light equipment's but in case of larger buildings it may require the use of a wrecking ball, cranes etc. Explosive demolition is the preferred method for safely and efficiently demolishing larger structures and skyscrapers.*

Building implosion is the strategic placing of explosive materials and timing of its detonation so that a structure collapses on itself in a matter of seconds, minimizing the physical damage to its immediate surroundings. Controlled demolition of building is necessary to ensure safety of both the workers and the surroundings so as to cause least amount of injuries and accidents.

Keywords-implosion, controlled demolition

I. INTRODUCTION

Every structure is designed for a life period. After that service life period its existence becomes very dangerous to its occupants and surrounding buildings. The building act usually contains provisions to control demolition works for the protection of public safety and to ensure adjoining premises and the site are made good on completion of the demolition. 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's, machineries, explosives or with manual techniques without affecting the surrounding. When explosives are used for this then the demolition process are called as an implosion.

Instead, the technique weakens or removes critical supports so that the building can no longer withstand the force of gravity and falls under its own weight. Implosion method is adopted for high raised buildings in urban areas, where the other demolition methods are not acceptable. When demolition of a building takes place, the owner must inform the council and permission for the same shall be obtained. Permission for demolition is not required if building to be demolished has a volume of less than 1750 cubic feet (49.56 cubic meters).

In the 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 concern for eco-friendly and sustainable development, the reuse of demolition wastes for construction purposes can prove to be a better alternative for demolition waste management.

In this paper the work is proposed to demolish building (G+3) by implosion technique which will gives better result than other methods of demolition of structure ,also dissertation work gives feasible solution for waste management generated from demolition work.

II. LITERATURE REVIEW

An extensive literature review has been conducted in line with the titled research plan to find out the current level of research and identify the gaps in study .the salient feature of the most relevant works are presented in following text.

Amrutha Mary, Vasudev. [1] (2014) have studied 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. For small buildings it is a simple process with light equipments but in case of Larger buildings it may require the use of a wrecking ball, cranes etc. Explosive demolition is the preferred method for safely and efficiently demolishing larger structures and skyscrapers.

M.G.Bhandari1[2](2013) has studied 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's, machineries, explosives or with manual techniques without affecting the surrounding . Demolition is a simple process for small buildings or houses. The building is brought down either manually or mechanically using large hydraulic equipment: elevated work platforms, cranes, excavators or bulldozers. Demolition work is to be performed safely and with number of different steps involved before and during the execution of a demolition process.

Sasha Rai [3](2009) has studied Building implosionis the strategic placing of explosive materials and timing of its detonation so that a structure collapses on itself in a matter of seconds, minimizing the physical damage to its immediate surroundings. Despite its terminology, building implosion also includes the controlled demolition of other structures, such as bridges, smokestacks, towers, and tunnels. A true implosion usually involves a difference between internal (lower) and external (higher) pressure, or inward and outward forces, hat is so large that the structure collapses inward into itself. In contrast, building implosion techniques do not rely on the difference between internal and external pressure to collapse a structure. Instead, the technique weakens or removes critical supports so that the building can no longer withstand the force of gravity and falls under its own weight. The placement of the charges and the sequential detonationtiming is if vitalimportance, allowing the collapse of the building induced by the weight of the structure.

Masullo Mark Loizeaux1 and Andrew E. N. Osborn, P.E[4](2006) have studiedon designing a building intended to be resistant to progressive collapse, it is instructive to consider this problem from the point of view of an implosion contractor who regularly demolishes buildings through explosives-induced progressive failure. All buildings want to fall down, but are prevented from doing so through their structural columns, walls and transfer girders. Innumerable ergs of potential energy are just waiting to be released. The implosion contractor creates a progressive collapse by releasing this energy through the sequential explosive removal of key structural supports, allowing gravity to do the remaining work, simultaneously using the minimum amount of explosives, creating the maximum amount of fragmentation, and minimizing the potential fly of debris. In this paper, we will explore several building structural systems and how their implosion has historically been achieved, comparing the amount of effort required in each system to affect an implosion as related to the susceptibility of that type of building to progressive collapse and identifying those types that lend themselves to it.

AaryaVimal [5](2013) has studied the demolition is the most commonly pronounced word in the construction industry. As per the new building rules in some of the western countries, the building should be demolished after its service period. Out of number of demolition methods, cost and time efficient method is the demolition using implosion. In the implosion the structure implodes with the help of minimum amount of explosives. To overcome the limitations of implosion, a silent technique using Soundless Chemical Demolition Agents have also been introduced.

R. Kamala, B. Krishna Rao [6](2012) have studied in this industrial world, recycling construction material plays an important role to preserve natural resources. These studies seek to greener environment since it seeks to develop recycle waste material for construction. The use of recycle aggregates and solid wastes from construction and demolition waste is showing a prospective application in construction and as alternative to primary and natural aggregate. It conserves natural resources and reduces the space required for land fill disposal. In the laboratory the crushed tile aggregate has been tried as partial replacement substitute to convectional coarse aggregate in concrete making of cubes, cylinders, beams. These were cast and tested for compressive strength, split tensile and flexural strength after a curing period of 7, 28, 56 days. The results indicate effectiveness of crushed ceramic waste as partial replacement of conventional coarse aggregate up to 40 percent, without affecting the design strength.

III. METHODOLOGY

Before beginning the actual work of demolition a structure, a careful study shall bemire of the structure which is to be pulled down and also of all its surroundings. This shall include study of the manner in which the various parts of the structure to be demolished are supported and how far the stage by stage demolition will affect the safety of the adjoining structures. A definite plan of procedure for the demolition work, depending upon the manner in which the loads of the various structural parts are supported, is prepared and approved by the engineer-in-charge and this is followed as closely as possible, in actual execution of the demolition work. Before the commencement of each stage of demolition, the engineer shall brief the workmen in detail regarding the safety aspects to be kept in view. It should be ensured that the demolition operations do not harm the safety of the adjoining structures. Also noise effect of the demolishing work on the surrounding structures should be kept to the minimum

1. Implosion technique:

Implosion is the strategic placing of explosive material and timing of its detonation so that a structure collapses on itself in a matter of seconds, minimizing the physical damage to its immediate surroundings. The technique weakens or removes critical supports so that the building can no longer withstand the force of gravity and falls under its own weight. The explosives are just the trigger for the demolition. It's gravity that brings the building down. Explosives are loaded and progressively detonated on several different levels of the building so that the building structure falls down on itself at multiple points. When everything is planned and executed correctly, the total damage of the explosives and falling building material is sufficient to collapse the structure entirely.In order to demolish a building safely, each element of the implosion must be studied ahead of time. This is done with the help of blasting expert.

1. The first step is to examine architectural blueprints of the building to determine how the building is put together.
2. Next the building is surveyed to study about the support structure on each floor.
3. Based on this data and drawing from past experiences with similar buildings, decide what explosives to use, where to position them in the building and how to time their detonations.

The main challenge in bringing a building down is controlling which way it falls. Sometimes, a building is surrounded by structures that must be preserved. In this case, the proceed with a true implosion, demolishing the building so that it collapses straight down into its own footprint (the total area at the base of the building).

The basic idea in implosion is to think of the building as a collection of separate towers. The blasters set the explosives so that each "building" falls toward the centre of the building. When they are detonated in the right order, the toppling building crash against each other and all of the rubble collects at the centre of the building. Another option is to detonate the columns at the centre of the building before the other columns so that the building's sides fall inward.

1.1.Details of Explosives Used:

Once it is figured out how to set up an implosion, it's time to prepare the building and selection of the explosives used for the demolition. Explosion is a physical phenomenon in which is a sudden release of energy that generates light, heat, noise and most importantly pressure, which results in a blast wave.

The most common explosives used in demolition are Trinitrotoluene called as TNT, Pentaerythritoltetranitrate called as PENT and Composition B called as comp B.When the chemical is ignited, it burns quickly, producing a large volume of hot gasin a short amount of time. For this study PETN is used for implosion of building.

The most common use of PETN is as an explosive with high brisance. It is more difficult to detonate than primary explosives, so dropping or igniting it will typically not cause an explosion, but is more sensitive to shock and friction than other secondary explosives such as TNT Under certain conditions a deflagrationto detonation transition can occur. PETN was used for these detonators because it was safer than primary explosives.Explosion energy: 5810 kJ/kg (1390 kcal/kg), so 1 kg of PETN has the energy of 1.24 kg TNT.

1.1.1 Quantity of Explosives.

The quantity of explosive to be placed depends upon the size of column and extent up to which it is to be destroyed. Depending on above requirements we placed 23 kg of explosive in corner 16 columns and 90 kg of explosive in middle 16 columns, because it was desired to destroy the middle column completely. No outer column was weakened so that the building collapsed towards its centre from both side.

1.1.2 Drilling of holes for placement of explosive:

The holes were drilled of about 25 mm to 30 mm dia. and about 20 to 30 cm deep depending upon quantity of explosive energy is required to break a particular support. In this case the building was planned to bring down on its footprint

1.2 Introduction to Finite Element Analysis:

The finite element method is numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in almost every industry. In more and more engineering situations today, we find that it is necessary to obtain approximate solutions to problem rather than exact closed form solution. It is not possible to obtain analytical mathematical solutions for many engineering problems. An analytical solutions is a mathematical expression that gives the values of the desired unknown quantity at any location in the body, as consequence it is valid for infinite number of location in the body.

1.2.1 Procedure for ANSYS Analysis:

Static analysis is used to determine the displacements stresses, stains and forces in structures or components due to loads that do not induce significant inertia and damping effects. Steady loading in response conditions are assumed. The kinds of loading that can be applied in a static analysis include externally applied forces and pressures, steady state inertial forces such as gravity or rotational velocity imposed (non-zero) displacements, temperatures (for thermal strain). A static analysis can be either linear or nonlinear. In our present work we consider linear static analysis. The procedure for static analysis consists of these main steps,

1. Building the model
2. Obtaining the solution
3. Reviewing the results

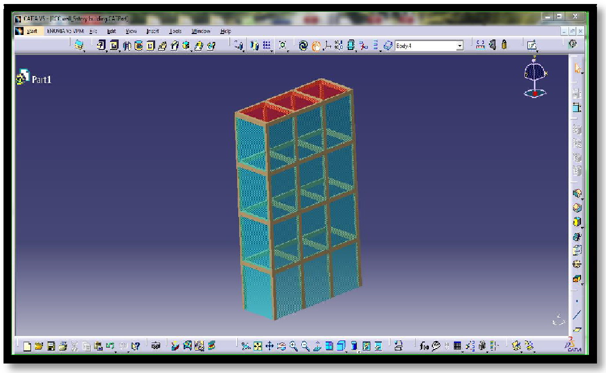

Fig.1 Geometry model of building (G+3)

Meshing of the design model:

For finite element meshing, first prepare three-dimensional (3D) model of building by using Pro-E software program. This ProE model is imported into HYPERMESH software, for finite element meshing. Instead of considering entire building, consider only one part of building, which consist of infinite number of degrees of freedom. To convert this infinite number of degrees of freedom into finite numbers, FE meshing of building is done. Building was modeled by cubic mesh element type, and this HyperMesh model is imported in the AUTODYN ANSYS software program, for the principle stress and displacement analysis.

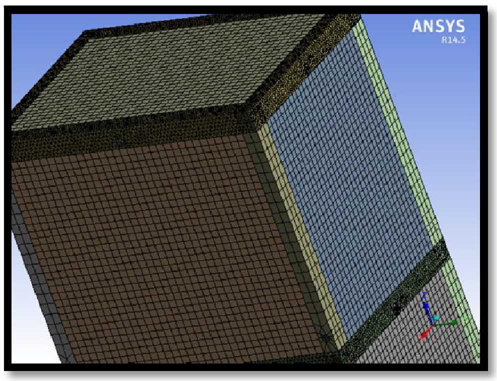

Fig.2 Meshing of the design model

1.2.2Placement for explosives:

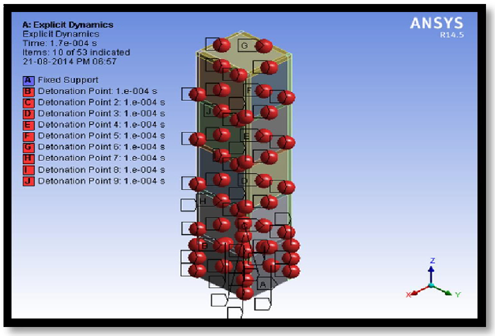

Fig.3 Proposed placement of explosive

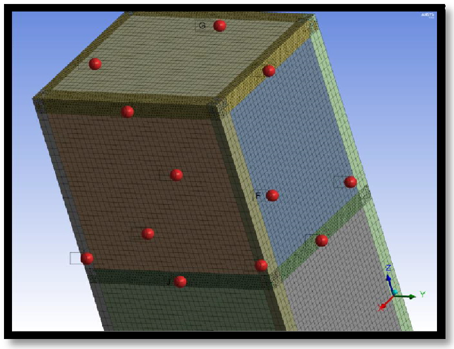

Fig.4 Modified placement of explosives

1.2.3 Implosion of building with PETN Explosive

A] Finite Element Analysis:

a) Principal stresses result by AUTODYNE ANSYS software for PETN explosive:

Here evaluation of the principal stresses generated at each detonation point after explosion is shown. These are evaluated by using finite element analysis. This analysis is done by using AUTODYNE ANSYS tool and explicit dynamics solver. Following are the results which gives maximum as well as minimum principal stresses; which is useful for location of explosion points.

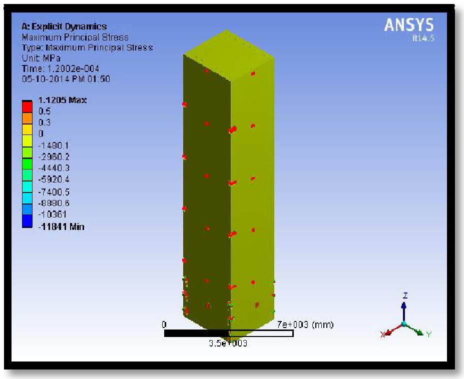

Fig.5 Principal stresses result by AUTODYNE ANSYS software For PETN explosive

From above fig. maximum principal stress generated at the point of explosion is 1.1205 MPa similarly, minimum principal stress is -11841 MPa. The red color indicates the maximum principal stress and blue color indicates the minimum principal stress generated after explosion.

b) Directional deformation result by AUTODYNE ANSYS software for PENT explosive:

Also it is required to evaluate the directional deformation generated at each detonation point after explosion. These are evaluated by using finite element analysis. This analysis is done by using AUTODYNE ANSYS tool and explicit dynamics solver. Following are the results which gives maximum as well as minimum directional deformation; which is useful for location of explosion points

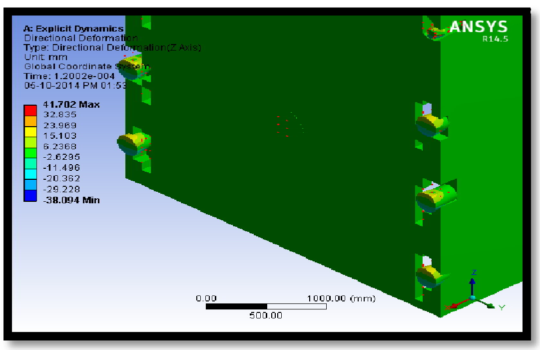

Fig.6 Directional deformation result by AUTODYNE ANSYS softwareFor PENT explosive

From above fig. maximum directional deformation generated at the point of explosion is 41.702 mm similarly, minimum directional deformation is -38.094 mm. The red color indicates the maximum directional deformation and blue color indicates the minimum directional deformation generated after explosion.

2. EXPERIMENTAL TESTING

Non-destructive testing (NDT) methods are techniques use to obtain information about the properties or internal condition of an object without damaging the object. Non-destructive testing is a descriptive term used for the examination of materials and components in such way that allows materials to be examined without changing or destroying their usefulness. NDT is a quality assurance management tool which can give impressive results when used correctly. The greatest disadvantage of the conventional methods of testing concrete lies in the fact that in-situ strength of the concrete cannot be obtained without damaging the actual structure

The test procedure is followed from IS: 13311 (Part 2) :1992 Non-destructive Testing of Concrete –Methods of Test, Part 2 Rebound Hammer Cl . 6 . 1 – 6 . 4 Cl . 5 . 2

Fig.7 Rebound hammer test

Above test gives rebound numbers and relative compressive strength of structural elements columns and beams the average compressive strength is 10.007 Mpa. Hence for structural analysis consider grade of concrete as M10

IV. RESULT AND DISCUSSION

Table 1: FEA results for PETN explosive

Sr.	Parameters	PETN Explosive
1	Principal Stress (Tensile), MPa	
	a)Maximum	1.1205
	b)Minimum	-11841
2	Principal Stress (Compressive), Mpa	
	a)Maximum	11.205
3	Directional Deformation,	
	a)Maximum	41.702
	b)Minimum	-38.094
4	Total Demolition Time, Sec	1.2002 e-
5	Total amount (Mass), kg	113.34
6	Explosive Cost. Rs/Kg.	2060

Table2: FEA and Experimentation result comparison for compressive strength of concrete

Sr.No	Validation Method	Compressive strength of concrete
1	Experimentation (Rebound Hammer Test	10.007 Mpa
2	Finite Element Analysis	11.205 Mpa

From the finite element analysis results, the maximum principal stress (Compressive) generated by PETN explosive is 11.205 MPa; while in the experimental test it is observed as 10.007 MPa.

V. CONCLUSION

Based on the present study the following conclusions were drawn:

After study of Finite Element Analysis results for the explosive PETN, for G+3 reinforced cement concrete structures it is observed that, PETN explosive is most suitable for the implosion of the building; because it generates maximum principal stress and directional deformation at predefined detonation points.

In this regards, the experimental test is carried out to determine the compressive strength of existing concrete structure, by using rebound hammer. The finite element analysis is carried out to study the suitability of PETN explosives for implosion of building. The compressive stress generated due to PETN explosive is more than stress in the existing concrete structure; hence it will implode building safely.

REFERENCES

[1] Amrutha Mary A, Vasudev. R., “Demolition of Structures Using Implosion Technology”, International Journal of Innovative Research in Science, Engineering and Technology,ISSN 2319-8753, Volume 3, Special Issue 5, July 2014, pp.401- 407.

[2] M.G.Bhandari, V.K.Kulkarni, R.K.Malviya, “Building Demolition: Ground to earth important as construction”, International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 3, Issue 4, April 2013, pp.396-401.

[3] Sasha Rai, “Building Implosion”, CIB Publication 498, March-2009, pp 234-239.

[4] Mark Loizeaux and Andrew E.N., Osborn P.E., “Progressive Collapse -An Implosion Contractor’s Stock in Trade”, Journal of Performance of constructed facilities © ASCE, DOI:10.1061/ASCE0887-3828, November 2006, Volume 20, Issue 04, pp.391-402.

[5] Aarya Vimal, Amrutha Mary, Vasudev R, Anju Paul, “Reuse of demolition waste for construction - A state of technology review”, American Journal of Engineering Research (AJER), ISSN 2320-0847, Volume 02, pp.39-42.

[6] Sara Kuikka,“ LCA of the Demolition of a Building”, Department of Energy and Environment, An assessment conducted at IVL Swedish Environmental Research Institute, Chalmers university of technology, Sweden, ISSN No.1404-8167,2012.

[7] R. Kamala, B. Krishna Rao,“Reuse of Solid Waste from Building Demolition for the Replacement of Natural Aggregates”, International Journal of Engineering and Advanced Technology (IJEAT), ISSN 2249-8958, Volume 02, Issue 01, October 2012, pp.74-76.

[8] Manal S. Abdelhamid, “Assessment of different construction and demolitionwaste management approaches”, Project Management Institute, Housing and Building National Research Center (HBRC) Journal, Egypt, January 2014,pp.01-10.