

Comparative Study of Demolition Methods

Arathy H. Menon¹, Dr. Geetha K. Jayaraj²

Student, Shivajirao S. Jondhale College of Engineering & Technology, Asangaon, Thane, Maharashtra, India¹.

Principal, Shivajirao S. Jondhale College of Engineering & Technology, Asangaon, Thane, Maharashtra, India²

Abstract – Demolition is defined as the process of destroying down or collapsing down of large buildings after its useful life. The demolition of concrete is common in most of the renovation and rehabilitation projects in the construction industry. For smaller structures, it is a simple process with lighter equipment and for larger structures, it may require the use of equipment, machineries, and explosives or with manual techniques without affecting the surrounding. In some projects, it may be required to confine the demolition to a small portion of the structure or to a shallow depth on a concrete member. Implosion is the method of demolition using explosives. The use of traditional demolition methods may not be feasible or may be required special precautions and procedures. A soundless chemical demolition agent (SCDA) is used for performing controlled concrete demolition on a small scale. This paper describes a comparative study on different methods of demolition and where they can be implemented.

Keywords: Demolition, Implosion, Soundless Chemical Demolition Agent.

I INTRODUCTION

Demolition of any structure is a ground to earth technique which means destruction of a building with the help of equipment, machineries, and explosives or with manual techniques without affecting the surrounding. The construction industry utilizes a variety of means for demolishing concrete. The use of jackhammers, hydraulic rams, wrecking balls, and explosives are examples of traditional demolition methods. High-pressure water blasting is another method that has been developed. When explosives are used for this then the demolition process are called as an implosion. High-pressure water blasting is another method that has been developed. Each of these methods has advantages that make it useful for various applications. It is sometimes the case, though, that these methods are limited in their use when the demolition work must be accurately confined to a small, defined area or depth, or when excessive noise, vibration, dust, or water is unacceptable. This situation may occur when the existing structure is sensitive to vibration, when the work is to be conducted in a dust-free area, or when the structure is of historic or architectural significance. When such limitations or concerns exist, other means for demolition may be required. Another means of demolition is the use of a soundless chemical demolition agent (SCDA).

II METHODS OF DEMOLITION

Demolition methods can vary depending upon the area where it will be held on, time available, building material, the purpose of demolition, the way of debris is going to be disposed. There different methods of demolition are explained below:

2.1 Piecemeal Demolition (Demolition by Hand):

Demolition of reinforced concrete buildings by hand tools such as electric, pneumatic breakers, jack hammers etc. are commonly being used. Oxy-acetylene torch may be used to cut the reinforcements. The reinforcements shall remain until all the concrete connecting to or supported by the reinforcement is broken away or when its supports are no longer required. Cantilever canopies, balconies and exterior walls are critical elements in building demolition which may be destroyed by piecemeal demolition method.

2.2 Mechanical Method

a) Excavators and Bulldozers:

Hydraulic excavators are used to topple one-or two-story buildings by an undermining process. The undermining process or erode the base or foundation which means to dig or excavate beneath the foundation and make it collapse. The strategy of excavation is to undermine the building while controlling the manner and direction in which it falls.

b) Wrecking Balls or Spilling Balls:

In those structures, which have heights greater than five stories machineries like normal excavators and bulldozers are not sufficient. In such cases crane with wrecking balls or spilling balls are used to demolish the structures. The wrecking balls are steel balls hanging from a steel rope which is attached to the crane. The wrecking balls act from outside. Demolition of building is done by the impact energy of the steel balls suspended from a crane tracked. [1], [2]

c) Pusher Arm Technique:

A Hydraulically powered pusher arm machine is mounted on tracked or wheeled chassis which is suitable for small masonry structure. Demolition by pusher arm involves the progressive demolition of a structure using machines equipped with a pusher arm attachment for applying horizontal thrust to progressively demolish the structural element, either by pushing into the structure or pulling out of the structure.

d) Hydraulic Shears:

Demolition with hydraulic shears involves cold cutting of metal and reinforced concrete sections by cutting and severing material using shear jaws. Shears attachments are

rigidly mounted to the machine or rotate to provide increased working versatility for cutting. Machines fitted with hydraulic shears may be considered for use where a wide range of materials, including metal sections and reinforced concrete are to be removed by cold cutting methods, and where materials are to be cut in situ. This method is considered for the processing of materials at ground level.

e) Pulverizer:

Mechanical demolition using a machine mounted pulverizer is the progressive demolition of reinforced concrete or brick structures by crushing the material with a powerful jaw action by closing the moving jaw(s) against the material. The pulverizer attachment may be considered for crushing beams, columns, floor slabs and panels either in-situ or as a subsequent processing operation, where reinforcing bars can also be separated. This is also used for the lifting and loading of steel and concrete beams and other solid materials.

f) Grapple:

A grapple is designed to use in primary demolition, such as steel and concrete beams, columns, walls and floor sections, and roof joists progressively to ground level. The jaws interlock to enable partial loads to be safely secured. The parallel-jaw closing action ensures that material is drawn into alignment approximately during the dismantling, lifting and loading cycle.

2.3 Thermic Lance Technique:

A Thermal Lance consists of steel pipe packed with mixed metal wires. Pure oxygen gas is provided through the pipe from an oxygen cylinder and regulator and the end of the pipe is lit with a high temperature source, e.g. an oxy-acetylene torch. The oxygen coming down the pipe helps to burn iron in the steel to produce enormous heat and a liquid slag of iron oxides and other materials, which dribbles and splashes out. The temperature in the centre of the combustion zone will reach approx. 4000 degrees Celsius, greater than the melting point of any substance on earth. Cutting of reinforced concrete by thermal lance is done at very high temperature up to 2000 to 4000°C. The extremely high heat requires special precautionary measures and care. The use of a thermal lance in cutting reinforced concrete may not be used unless the project demonstrated that there is no other viable alternative. This procedure is ideal for demolitions where vibrations and noises are unacceptable or where is desired a high work speed. [11]

2.4 Water Jet:

The Jet heads are generally small and so action of jet which contains water with high pressure is mainly to loosen the aggregate by washing out softer. Water jetting involves the use of a water jet stream pumped at high pressure to erode the cement matrix and wash out the aggregates which is known as hydro demolition. For cutting reinforcing steel, abrasive compounds are added. The water used in the operation may be disposed or may be recycled for continuous operation through local filtration and sedimentation. Provisions shall be made for

these operations. The area which is to be cut behind the structural member should be shielded to avoid damage to persons and properties during the cutting. All site personnel should wear adequate safety cover and clothing.

2.5 High Reach Excavators

High reach demolition excavators are used for tall buildings where explosive demolition is not appropriate or not possible. These excavators are used to demolish those structures having height up to 300 feet. Some attachments are also provided for specific purposes. For example, shear attachments can be provided in these excavators which are typically used to dismantle steel structural elements. Hydraulic hammers are mostly used for concrete structures and concrete processing attachments are used to crush concrete to a manageable size, and to remove reinforced steel.

2.6 Cutting and Lifting

Cutting and lifting involves the steps as the initial cutting of the structure into individual pieces or segments, and then lifting the pieces or assembly by crane onto the ground for further demolition or hauling away. Slabs are cut into segments and then lifted off for further cutting into smaller pieces before disposal. Precast concrete structures are also cut into pieces and then lifted off as a reversal of the construction sequence when the precast elements are fabricated from pieces into an assembly of structure. This method may be applied to remove projections such as canopies, architectural features, balconies and bay windows safely.

2.7 Non-Explosive Demolition Method**a) Soundless Chemical Demolition Agent:**

Soundless chemical demolition agent (SCDA) is a non-explosive demolition method. SCDA's consist of substances such as lime calcium oxide, (CaO), aluminium oxide (AL₂O₃), magnesium oxide (MgO), ferrous oxide (Fe₂O₃), silica (SiO₂), and calcium fluoride (CaF₂), which are commonly added to affect and control the rate of hydration of the SCDA slurry. The destructive power of SCDA's is generated when the material is mixed with water and hydrates within a confined space. [1] Depending on the type of SCDA, significant expansive pressure may be generated as quickly as within 15 min., or as long as within 24 hr [3]. One drawback of SCDA is cost. When compared to common explosives, such as dynamite and ammonium nitrate SCDA are often more expensive. [7]

2.8 Concrete Sawing Method

Concrete saw helps to demolish the structure which works on a high-power supply. Saw cutting method is suitable for alteration and additional works where accuracy is important. In this method, the tolerance to noise and vibration is very limited. Concrete saw can be used to cut concrete slabs and wall elements into segments. By saw cutting method an entire building can be dismantled This method of cutting generally includes conventional disc saw and chain saw, diamond core stitch drilling and wire saw. Wire saw cutting

comprises a special steel wire often impregnated with diamond beads to increase its cutting ability. The wire saw method is a suitable for those projects which require total control on demolition work. A hole must be pre-drilled for the passage of the diamond wire, after that wire cutting operation follows. Because of its flexibility, it may be used for “hard to reach” areas. A diamond wire saw can be used in cutting off piling of marine structures and bridges. Saw cutting and controlled lowering was determined to be the only feasible method of chimney demolition. [8]

2.9 Implosion

Implosion describes the process of using minimum number of explosives with minimal structural preparation expense to get a structure to collapse in a controlled fashion. Implosion implies a collapse from external pressure which is technically incorrect. A true implosion usually involves a difference between internal (lower) and external (higher) pressure, or inward and outward forces, that are so large that the structure collapses inward into itself. [2] If we remove the support of the structure of a building at a certain point, the section of the building above the point will come down on the part of the building below that point from where it is exploded. [5] 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. Implosion method is adopted for high raised structures in urban areas, where the other demolition methods are not applicable. Implosion is the process which demolishes the building in such a way that it collapses straight down into its own footprint. A good design will cause the structure to fall towards the centre of the building & within the protected area. [10]

III COMPARATIVE STUDY OF DEMOLITION METHODS

Demolition method applied in a structure decided on the basis of 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. Controlled demolition of building is necessary to ensure safety of both the workers and the surroundings to cause least amount of injuries and destruction. Implosion of building 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. Building implosion can be applied for the controlled demolition of other structures, such as bridges, smokestacks, towers, and tunnels. Each method is useful as per the requirement of the site. The comparison between principle and implementation of each method is explained in Table No.1.

Table 1: The comparison between principle and implementation of each method

Method	Principle	Implementation
1.Piecemeal Demolition	Carried out top to bottom, proceeding in general from the roof to ground and manual demolition	-Manual method -Rope or tie wires used to pull down the structural elements -Extra caution should be taken -Reinforcement will remain until, the concrete remove completely -Hammer produce a repeated impulse to break the structure
2.Mechanical Method	Carried out top to bottom and demolition done by machines	-Demolition done by machines -Lifting the mechanical plant to the top of the building -Movement of the mechanical plant should be with in the area
a) Excavators and Bulldozers	Used to topple one or two story buildings by an under-mining process	-Dig or excavate beneath the foundation so as to make it collapse
b) Wrecking Ball	Destruction of the building by the impact energy of the steel ball suspended from the crane	-Operates from outside the building -Used where local environmental issues and asbestos or lead building component -Require sustainable clear space -High level skilled operation -Work from top to bottom -Minimize dust impact on the surrounding area by

		<p>presoaked the building</p> <ul style="list-style-type: none"> -Can't use on steel structures -Less control on moving ball -More force required -Produce repeated vibration
c) Pusher Arm Technique	Applying horizontal thrust to progressively demolish the structural element	<ul style="list-style-type: none"> -Hydraulically powered pusher arm machine is mounted on a tracked or wheeled chassis -Demolish the structural element either by pushing into the structure or pulling out of the structure
d) Hydraulic Shear	The crusher attachment breaks the concrete and the reinforcement by hydraulic thrust through the long boom arm system	<ul style="list-style-type: none"> -Can be operated from the ground, outside the building -Suitable for dangerous buildings silos and other industrial facilities -Operation shall have a minimum clear Space for safety zone.
e) Pulverizer	Crushing the material with a powerful jaw action	<ul style="list-style-type: none"> -Progressive demolition of reinforced concrete or brick structures -Jaw action by closing the moving jaws against the material -Demolish and reduce concrete in a single step -Separating rebar from concrete
f) Grapple		-Use in primary demolition and re-handling applications.
3. Thermal Lance	The thermal lance is capable of processing by thermal cutting high melting materials and at high functioning temperature is capable to cut virtually any material	<ul style="list-style-type: none"> - Created by packing a seamless mild steel tube with low carbon rods and passing oxygen through the tube -Eliminates vibrations and dust problems -Restriction on noise -Possible to cut carbon alloyed steel and high alloyed steel, cast iron and non-metallic materials like bricks, concrete etc. -Creates hazardous associated with smoke and fire danger
4.Saw Cut Method	Saw cutting generally includes conventional disc saw and chain saw, diamond core stitch drilling and wire saw	<ul style="list-style-type: none"> -Accuracy in the cutting -Suitable for alteration and additional works -Restriction on noise and vibration -No dust because of the cooling water -Diamond blade saws are limited in depth of cut they can make.
5. Water Jet Method	High pressure supersonic water jet penetrates the pores and cracks of the concrete and built an internal pressure which exceeds the tensile strength and cause concrete break	<ul style="list-style-type: none"> -Minimizes dust -Eliminate vibration and fire hazardous -Used for cutting straight lines, contours and make access manholes -Minimum labour resulting in reduced cost -Greater production rate, resulting in faster project completion -Hydro demolition removes less sound concrete than hammering does
6.Highreach Demolition Method	Work from the ground and different attachments for various works	<ul style="list-style-type: none"> -No distortion to the surroundings -Less risk factor -Work from the ground -Different attachments for various works -Quick and Reliable



		<ul style="list-style-type: none"> -Controlled Demolition -Used for tall buildings where explosive demolition is not appropriate or not possible
7. Cutting and Lifting	Initial cutting of the structure into individual pieces or segments, and then lifting the pieces or assembly by crane onto the ground for further demolition or hauling away	<ul style="list-style-type: none"> - Applied to safely remove projections such as canopies, architectural features, balconies and bay windows -Prior to cutting, the stability of the remaining structure shall be checked. -The structural element to be removed shall be secured, either by temporary supports or by tie wires connected to lifting appliances - After cutting, the structural element shall be lowered to the designated area in a controlled manner
8.Soundless Chemical Demolition Agents (SCDA)	The destructive power of SCDA is generated when the material is mixed with water and hydrates within a confined space	<ul style="list-style-type: none"> -Holes are drilled into the concrete and filled with a slurry made from SCDA and water. -The slurry begins to hydrate, generating heat and crystallizing. The crystallization process expands the material and exerts significant expansive forces that fracture the surrounding concrete -Do not make noise, explode or generate fly rock -No vibration or toxic fumes -Free from the threat of premature explosion -Cost is high -Used for breaking up boulders. small scale demolition -Demolition of concrete structures near inhabitant area, road ways etc.
9.Implosion	The process of using the minimum number of explosives with minimal structural preparation expense to get a structure to collapse in a controlled fashion	<ul style="list-style-type: none"> - 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 -Less expensive -Quickest method -No ground vibrations -Suitable for multi-storeyed buildings, high piers -Generate fly rock -Small carelessness lead to huge damage -need of experience hand

IV SUMMARY

Depending upon various factors such as site condition, type of structures, age of building, height of building and economy. The most important is its location with presence of its surrounding and its structural stability, the method of demolition is selected. However, Implosion is the fastest method among these demolition methods. Implosion method is less expensive compared to other methods and suitable for high rise buildings. Demolition by Soundless Chemical Demolition Agents is used in the inhabitant area, road way etc. and its cost is high. High Reach excavators are used for high rise buildings where implosion method cannot be used. Manual method and Mechanical method of demolition are used for small buildings. Manual method is used in congested areas. Concrete sawing method is used at the places where accuracy in cutting is important such as alteration and additional works. Cutting and lifting method is applied to safely remove projections such as canopies, architectural

features, balconies and bay windows. In Water jet method, minimum labor is used and thus reduces the cost. Thermal Lance method are used to cut carbon alloyed steel and high alloyed steel, cast iron and non-metallic materials like bricks, concrete etc. Thus, each method is used as per the situation.

REFERENCES

[1] John A Gambatese, (2013), "Controlled Concrete Demolition using Expansive Cracking Agent", J. Constr. Eng. Manage. 129 (1):98-104.
 [2] Amrutha Mary, Vasudev R, (2014), "Demolition of Structures using Implosion Technology International Journal of Innovative Research in Science, Engineering and Technology," Volume 3, Special issue 5.
 [3] Jimmie Hinze and James Brown, (1994), "Properties of Soundless Chemical Demolition Agents," J. Constr. Eng. Manage., 120 (4):816-827.
 [4] A T M Mozaffor Hossain, (2012), "The Contribution of Controlled Demolition (CD) towards disaster Effects



Reduction,” BUP Journal, Volume 1, Issue 1, and ISSN: 2219-4851.

[5] M.G.Bhandari, V.K.Kulkarny, R.K.Malviya, (2013), “Building Demolition: Ground to Earth Important as Construction By International Journal of Emerging Technology and Advanced Engineering,” Volume 3, Issue 4.

[6] Mark Loizeaux and Andrew E.N. Osborn P.E., (2006), “Progressive Collapse- an Implosion Contractor’s Stock in Trade,” J. Perform. Constr. Facil, 20(4):391-402.

[7] Jimmie Hinze and Andrew Nelson, (1996), “Enhancing Performance of Soundless Chemical Demolition Agents,” J.Constr.Eng.Manage.122 (2):193-195.

[8] Kenneth K Walker, Cliff Schexnayder, Richard E Mayo, and Kenneth D Walsh, (1996), “Methods of Procedural Considerations in Demolishing Tall Concrete Chimneys,” J.Constr.Eng.Manage.,122(3):223-230.

[9] Osama Abudayyesh, Anil Sawhney, Hossam El-Bibany and David Buchanam, (1998), “Concrete Bridge Demolition Methods and Equipment,” J. Constr. Eng. Manage., 3(3):117-125.

[10] Shweta O. Rathi, and P.V. Khandve, (2014), “Demolition of Buildings – An Overview,” International Journal of Advance Engineering and Research Development (IJAERD) Volume 1, Issue 6, e-ISSN: 2348 - 4470, print-ISSN: 2348-6406.

[11] S. Deepan and G. Manikandan, (2016), “A Critical Study on Various Demolition Equipment’s and Techniques and Assessing the Usage of Thermal Energy for Demolition of Steel Structures,” IJIRSET Vol. 5, Issue 2.

[12] Hossein Foruzesh, (2016), “Study of the causes of deterioration and new methods of demolition of concrete and metal structures,” International Academic Journal of Science and Engineering Vol. 3, No. 4, pp. 11-22.