

Reuse of demolition waste for construction - A state of technology review

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Abstract: - 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. Since now-a-days the importance is given to sustainable and environmental friendly construction, there should be effective control of the demolition waste. The demolition waste can be reused for the construction.

Keywords: - Demolition, Implosion, Sustainable

I. INTRODUCTION

Every structure is designed for a life period. The existence of the structure after the service life period is very dangerous to its occupants and surrounding buildings. So removal of such structures with proper safety measures is importance. Among the various techniques in demolition, the most cost and time efficient method is implosion. Implosion is an art of placing the explosive material and its detonation timing, in such a way that the structure collapses on itself in a matter of seconds, minimizing the structural damage to its immediate surroundings. In this method, the vertical supports are weakened, so that the building can no longer withstand the force of gravity and falls under its own weight.

Sometimes this method cannot be adopted due to many reasons. Such a situation arises when the demolition work must be accurately confined to a small defined area or depth, or when excessive noise, vibrations, dust or water is unacceptable or the existing structure is sensitive to vibrations or when the work is to be conducted in a dust free area, or when the structure is of historic or architectural importance. These situations along with widespread environmental considerations led to the development of a new method of demolition using Soundless Chemical Demolition Agents (SCDAs), also known as Soundless Cracking Agents, Expansive Agents, Expansive Concrete, Non-Explosive Demolition Agents and other related variations of such terms.

II. THE TECHNIQUE OF IMPLOSION

Implosion is the process of violent bursting inward that allows the sequential elimination of structure supports. Enough explosives are used to eliminate the critical vertical structural supports. The placement of the charges and the sequential detonation timing is of vital importance, allowing the collapse of the building induced by the weight of the structure. Implosion demolition methods are used in urban areas and often involve large structures.

After satisfying the legal aspects and preliminary steps of the demolition activity, the Blasters (those who are certified in blasting), examine the site several times and finalize the explosives used for the demolition activity. For example, if it is a steel structure, RDX is used as explosive, whereas in concrete structures, Dynamite is used as explosives [1]. The amount of explosive needed is calculated based on the thickness of the material, performance in the test blast and from their past experience [2]. After that the blasters load the columns with explosives. To measure ground vibrations and air blasts during an implosion, portable field seismographs are used. The safety clearance shall not be less than 2.5 times the height of the building [2]. To reduce the flying debris, the columns may be wrapped with chain linked fencing or geotextile fabrics. After the site is cleared, the

blasters detonate the explosives. The actual implosion takes only a few seconds. The structure is then examined by the blasters and the remedial measures are adopted.

Sequence of detonation in Implosion

The concept of implosion is to create an almost fluid motion in the collapse of the building, and this concept reduces the ground impact and resultant vibration. Columns at the lower bottom of the building are detonated first, to make maximum amount of potential energy available immediately to get the progressive collapse. When a column is detonated, the structure above begins to accelerate towards the ground at less than 10 m/ s² (32.2 ft/ s²) freefall [1]. During a building implosion, the detonations are timed so that just before the alternate load path is created, the adjacent column line is detonated to allow continuity of the progressive failure. Therefore, assuming freefall, if there was a one second delay between adjacent column lines, the column line just detonated would have dropped almost 5.2 m (16 ft), thereby impacting the ground before the next column line is detonated. This eventuality is to be avoided as a premature ground impact by a portion of the structure may redirect the still standing portions into unexpected directions [1]. The equation showing the freefall distance ($\frac{1}{2}gt^2$) is shown in the Table.1. The exact delay interval between column lines is determined by the implosion contractor based on experience and projection of historic data against the structural configuration at hand.

Table .1 Basic physics of free fall

Time(t- sec)	Distance (d-m)	Velocity (v-m/s)
0.00	0	0
0.25	0.33	2.60
0.50	1.3	5.20
0.75	3.00	7.80
1.00	5.20	10.50

The fundamental physics in building implosion involves the conversion of potential energy to kinetic energy. When the columns at lower levels are removed, the rest of the building will come down and additional explosives provided in the upper levels will ensure the continuity of the desired collapse mechanism.

III. INTRODUCTION OF SILENT DEMOLITION TECHNIQUES

To overcome the limitations of the implosion technique, a new approach has been developed using Soundless Chemical Demolition Agents (SCDAs) in the construction industry, especially in renovation and rehabilitation projects. SCDAs are lime based chemicals that are able to replace traditional explosives in fracturing concrete or large rock boulders to manageable sizes or to demolish rock and concrete structures. The advantages of the SCDA can be figured out easily with the comparison of SCDAs with other methods of demolition shown in Table.2. This implies that they can be used in environmentally sensitive areas where explosives are prohibited.

Table.2 Comparison of SCDAs with other means of demolition

Kinds	Breaking Power	Situation at the work site				Safety	Simplification of protection	Economy
		Noise	Ground Vibration	Dust Gas	Fly rock			
Explosives (dynamite)	High	High	High	High pollution	High pollution	Least	Least	Cheapest
Concrete cracker	Good	Inferior	More	High pollution	More pollution	Least	Least	Cheapest
Rock breaker	Inferior	Inferior	Less	Less pollution	Pollution free	More	High	Cheaper
Hydraulic splitter	Good	Noiseless	Vibration free	Pollution free	Pollution free	High	High	Costly
SCDA	Good	Noiseless	Vibration free	Pollution free	Pollution free	High	High	Costly

SCDAs resemble Portland cement in appearance. SCDA is a grayish brown powdery substance consisting of Lime or Ca O (81-96%), Aluminium Oxide (Al₂O₃ 0.3-5%) , Magnesium Oxide (Mg O 0-1.6%), Ferrous Oxide (Fe₂O₃ 0.2-3%), Silicon (SiO₂ 1.5-8%), Calcium Fluoride (CaF₂). Lime is the primary ingredient and the additives are added to alter, delay, enhance or control the hydration of SCDA.[3]

Action of SCDA's

Initially boreholes must be drilled in the required structure to contain the SCDA. The SCDA should be mixed with a measured quantity of water and poured into the boreholes in a slurry form. It will then begin to hydrate to about 1500 °C and crystallizing while hardening and expanding. If the hydration takes place under confinement, the crystallization process expands the material and exerts significant expansive forces. It is noted that, on hydration, the volume of the material nearly triples over several hours along with the generation of pressure and development of Ettringite crystals. When the expansive pressure exceeds the tensile capacity of the rock or concrete, cracking of the in-situ material occurs. After the chemical reaction is completed, the SCDA's re-solidify to a low strength material that easily disintegrates. [3]

Traditional blasting agent quantities are based on the homogeneity, strength, density, rate of energy propagation and the elasticity of the material being fractured as well as borehole spacing, depth and size. For SCDA's, water, temperature, moisture content and ambient temperature are additional factors. Temperature is directly related to expansive pressure generation and is the most important factor, whereas water to SCDA ratios is inversely related. Borehole diameter is not considered to be a significant factor for expansive pressure generation.[4]

The use of SCDA's to break up concrete structures such as thick slabs or foundations, typically involves placing the material in holes that range from approximately 25.4 to 50.8 mm (1 to 2 in) in diameter. The holes are to be drilled to a depth of 0.15 to 3 m (0.5 to 10 ft), spaced from 0.15 to 0.61 m (6 to 24 in) apart, depending on the amount of cracking desired and the size of the object to be demolished. [4].

IV. EFFECTIVE CONTROL OF DEMOLITION WASTE

Demolition waste is waste debris from destruction of a building. The debris comes from insulation, electrical wiring, rebar, wood, concrete, and bricks. It also may contain lead, asbestos or different hazardous materials. It is possible to recycle many elements of demolition waste. For instance, rubble can be broken down to manageable sizes and reused in construction projects. Waste wood can also be recycled. Reuse initiatives are of the primary concern, as reuse provides the most efficient use of natural resources and frequently yields the greatest economic benefit. Proper planning prior to commencement of the project will facilitate the identification of reuse options.

Reuse of demolition wastes can include a range of activities such as:

- Reuse materials on-site in rebuild stage of the project (e.g. doors, raised flooring, demountable drywall partitions, and using masonry as backfill).
- Classify and reuse materials for another off-site project.
- Separating building materials and handovering to used building materials centre for resale.
- The additional project time and labour costs needs to be planned figure out and included in the diversion work plan.

V. DEMOLITION WASTE MANAGEMENT CASE STUDY

There are a number of excellent examples of building projects which have diverted significant amounts of demolition waste from landfill. One of them is described briefly below.

A Study on Reuse of demolition wastes in Green Floors Project, Ontario

Natural Resources Board of Canada is devoted to the promotion of resource conservation and environmentally sustainable technologies. For this purpose, the Green Floors Initiative was developed for the Board headquarters located at 580 Booth Street in Ottawa. The building was owned by the Department of Public Works and Government Services (PWGSC). The Green Floors Project was focused on improved energy efficiency and to add the best available construction products and processes during demolition and construction, which reduced the environmental impact. The demolition of the 13th floor was accomplished in February and March of 1995 and served as the blueprint for the 7th floor demolition that was scheduled for January of 1996.

Reuse of materials in the site was done in the following manner:

- The glass fiber ceiling tiles were carefully removed to facilitate reuse. The level of care that was used in the tile removal resulted in over 90% of the tiles being diverted from the waste stream.
- Power source poles have a high value and are often salvaged from demolition sites. This product is primarily metal. It was important that these poles were removed carefully to prevent any damage that would limit their reuse.
- Demountable partitions were carefully dismantled to maximize reuse.
- Mineral fiber ceiling tiles are a different type of product and are traditionally sent to landfills. Salvage and resale of over 90% of this material was considered a success.
- All of the power source poles were salvaged for resale.

- Insulation can easily be reused on future construction sites. As the contractor was conducting another renovation in the same building, over 30 m² of insulation was reused. The remaining insulation was bundled into the salvaged draperies and sent for resale.
- Serviceable areas of the carpet were cut into 3m x 6m sections and sent for resale.

VI. CONCLUSION

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, provided sufficient researches are carried out in this field.

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