SCIENNOVATION
A Journal of Structural Science and Innovation

Review Article

Date Received: 20. February.2020
Date Accepted: 04. March.2020

Controlled Demolition Techniques and Demolition Direction

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Keywords:
Demolition, Demolition Techniques, Building Renewal.

Abstract

Every structure has a service life that can be used safely. The demolition works of the buildings that complete the period of use are quite troublesome. Various demolition techniques have been developed by structural engineers over time. The main purpose of this study is to compare demolition techniques with their advantages and disadvantages. The most important problem with demolition works is safe operation. In this article, the necessary techniques have been investigated to perform the demolition work safely in the desired direction.

Kontrollü Yıkım Teknikleri ve Yıkım Yönü

Anahtar Kelimeler;
Blok Zinciri, İnşaat mühendisliğinde Blok zinciri uygulamaları.

Özet

Her yapının güven içinde kullanılabileceği bir servis ömrü vardır. Kullanım süresini tamamlayan yapıların yıkım işleri ise oldukça zahmetlidir. Yapı mühendisleri tarafından zaman içinde çeşitli yıkım teknikleri geliştirilmiştir. Bu çalışmanın başlıca amacı yıkım tekniklerini avantaj ve dezavantajlarıyla karşılaştırmaktır. Yıkım çalışmaları ile en önemli sorun güvenli çalışmadır. Bu makale kapsamında yıkım işinin istenilen yönde güvenli biçimde yapılabilmesi için gerekli teknikler araştırılmıştır.

1. INTRODUCTION

Turkey has a large existing building stock has completed its service life. These existing structures need to be renewed for four different reasons. These reasons are;

1. End of life of structures,
2. Non-compliance with structure specifications and regulations,
3. Structural and design weaknesses against earthquakes,
4. Natural disasters, wars etc.

The reasons for urban transformation include place requirement due to increasing population, revisions in the zoning plans and rapid urbanization factors. When the data of the Turkish Statistical Institute were examined, the urban transformation rate was 25% in the early 1950s, 40% in the 1980s, 65% in the early 2000s, 77% in 2012, 91.5% in 2014, 92.1% in 2015 and 92.5% in 2017. This increase in urban population day by day causes housing shortages. Due to the growing housing shortage, renovation or demolition of older dwellings has become important. Due to the need for housing due to urbanization and the presence of structures damaged by natural disasters, it is predicted that more than 6000000 houses will be demolished and rebuilt in our country in twenty years.

2. DEMOLITION TECHNIQUES

Within the scope of urban transformation in our country, many studies have been carried out and new techniques have been developed to ensure that the demolition or renovation of old and inadequate structures can continue more effectively. Techniques used for complete or partial destruction of structures can be classified as follows (Koca, 2006):

- Demolition by crushing or by breaking or by separating with mechanical tools,
- Demolition by hitting the structure with the help of a vince-attached steel sphere,
- Demolition with high-access machines and scissors machines,
- Demolition by tow rope,
- Controlled demolition by explosives,
- Demolition by floor reduction method,
- Demolition of the structure by breaking down with chemical materials,
- Demolition of the elements of the structure with diamond saws.

Although there are many techniques developed for the demolition work, the technique that provides the most suitable conditions for demolition work must be selected. When selecting the most suitable technique to use for a demolition job, the following elements are taken into account:

- Cost of demolition work and allocated time for demolition,
- Determination of whether demolition work is partial or complete,
- Determination of whether the field capacity for mechanical vehicles is sufficient,
- The quality of the material used in the structure to be demolished,
- Geometry of the structure or structural elements to be demolished,
- The size and location of the structure to be demolished (Koca, 2006),
- Environment and traffic situation of the structure to be demolished,
- The properties of the ground where the structure is built and the structural system of the structure,
- Equipment supply, demolition experience and occupational health and safety precaution,
- Safety of demolition work and presence of hazardous materials,
- Allowable level of disturbance (noise, dust and vibration),
- Reuse of rubble after demolition.

Some of demolition techniques are shown in figure 1.

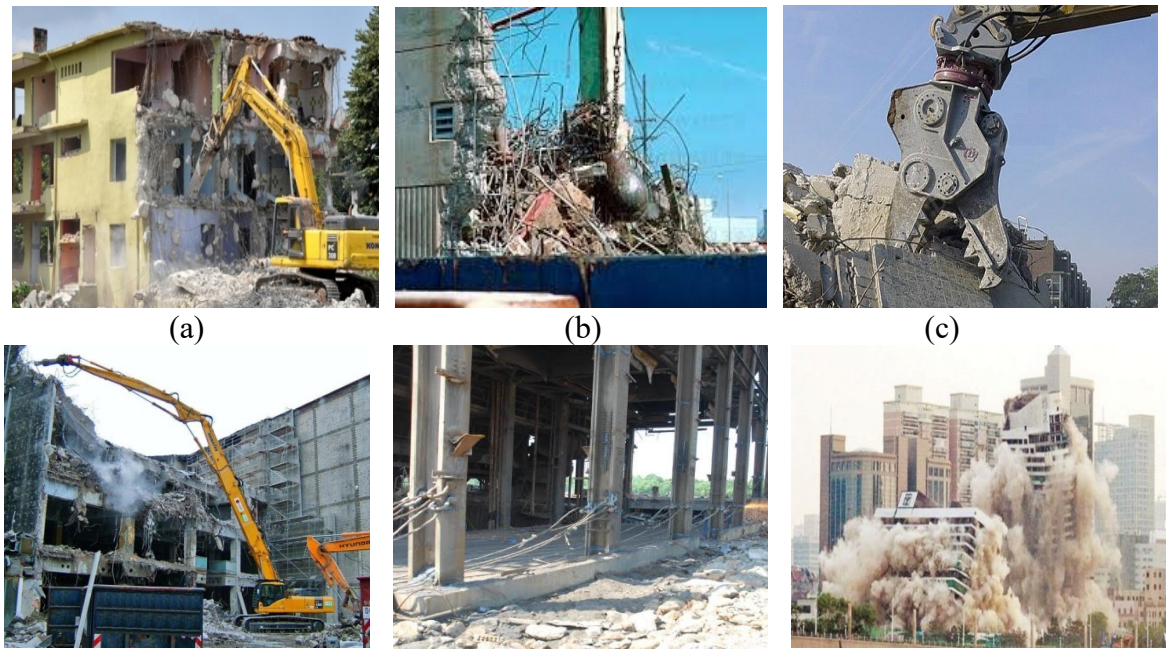


Figure 1. (a) Destruction by mechanical tools, (b) Destruction by steel sphere, (c) Demolition with concrete shears, (d) Demolition with high access machine, (e) Demolition by tow rope, (f) Demolition by explosive.

The three most important of these elements; location, dimensions and cost of demolition.
The destruction of these structures by traditional methods by inexperienced and uninformed people leads to dangerous consequences. On November 23, 2017, that the chimney above the demolished block toppled over the excavator in the Triangle Bazaar in Denizli (Figure 2 (a)) ("Denizli'de yıkımı yapılan", 2017) and on January 8, 2017 that the overturning of the mechanical vehicle during the demolition of the 6-storey building in Battalgazi District of Malatya (Figure 2 (b)) ("Malatya'da yıkım yapan", 2017) are examples of these dangerous consequences.

(a) Demolition accident in Denizli

b) Demolition accident in Malatya

Figure 2. Example Demolition Accidents

In order to continue urban transformation activities quickly and effectively in our country, controlled demolition method by explosives should be preferred instead of traditional demolition methods.

3. CONTROLLED DEMOLITION BY EXPLOSIVES

Controlled demolition technique by explosives of the structures is based on the principle that the carrier elements in the lower floors of the structure are broken down by explosives and the other carrier elements lose their carrier properties under the influence of increasing forces.
The advantages and disadvantages of the demolition technique by explosives compared to traditional demolition techniques can be summarized as follows.

Advantages of demolition technique by explosive:

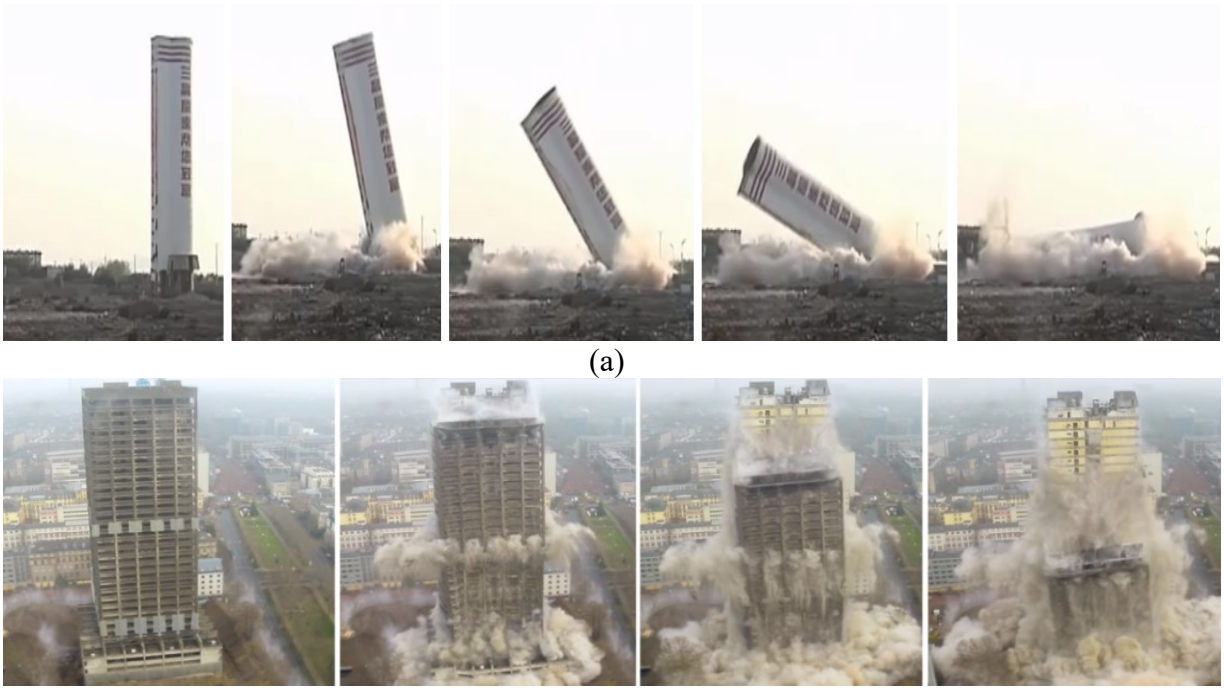
- Lower cost, especially when applied in higher structures,
- Faster application than other demolition techniques,
- Disturbances limited to a short time,
- Safer when carried out on or near traffic arteries,
- It can be used in situations where the use of construction machines is difficult,

Disadvantages of demolition technique by explosives:

- If there is no project of the building to be demolished and the material properties of the building are not known, data collection may lead to time loss,
- The necessity of a team of expert and experienced people in explosive, static and security issues for demolition work (Koca, 2006),
- To obtain the necessary permits for detonation is time consuming,
- The necessity of stopping traffic flow around detonation (Jimeno ve diğerleri, 1995),
- Potential danger risk of explosives,
- Possibility of damaging nearby structures,
- The possibility that the structure will not be completely demolished.

Two methods are commonly used for controlled destruction of structures by explosives . The first of these is based on the principle that the structure is toppled sideways as a result of changing the centre of gravity of the structure (Figure 3 (a)). The second is based on the principle that the structure collapses within the boundaries of the structure as a result of the loss of the carrier properties of some of the carrier elements of the structure (Figure 3 (b)).

It is possible to come across applications where these two methods are used together.



(a)

Figure 3. (a) Toppling of the structure and (b) Collapse of the structure within its boundaries

The firing sequence in toppling the structure to the side starts from the carrier elements which are in the direction of the toppling and continues in a delayed way towards the carrier elements in the inner parts of the structure. The firing sequence in the inward collapse of the structure starts from the carrier elements that are near the centre of gravity of the structure and continues towards the carrier elements that are located at the edges. Detonation of the carrier elements by using milliseconds-delayed capsules will increase the loads on the other structural elements, so the structure will start to deform itself. In non-delay explosions or explosions with very little delay time, the structure does not have the time to deform itself (Özyurt, 2013). The delay intervals determined according to the demolition direction of the structures are shown in Figure 4(a) and Figure 4(b).

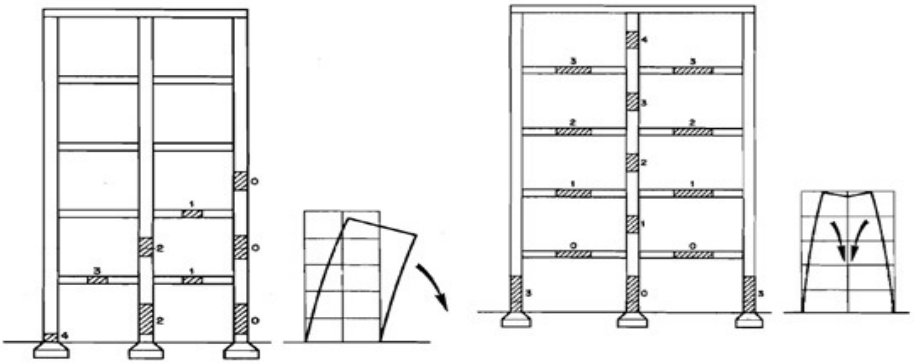


Figure 4. (a) Toppling the structure in a certain direction and (b) Collapse of the structure within its boundaries

In this demolition technique, the material properties of the structure, the selection of the elements, the design of the hole geometry in which explosives will be placed, the type and amount of explosives to be used in the demolition, the firing system to be used must be determined by the experts in the demolition area (Doğan et. al., 2009). Due to the diversity of features, such as properties of materials used in the structure, location of the structure and purpose of demolition, etc., the most suitable blasting and firing design of each structure is different (Olofsson, 1980; Özyurt, 2013). For example, if there is no space of sufficient size for demolition, the inward collapse method can be preferred. If there is, toppling method can be preferred.

Dangerous results can occur if the dynamic effects of the structure planned to be detonated are not calculated correctly or if the explosion sequence of the elements that are the most important stage of the controlled detonation technique is not properly determined. For example, on November 10, 2010, the tower of the Mad River Power Station in the USA State of Ohio was demolished on solid power lines, not in the direction it was planned after the explosion of the dynamite (Figure 5 (a)) ("Yanlış hesap kuleyi", 2010). The 10-storey structure, which was intended to be demolished by explosives in Sevastopol on 26 December 2014, was not demolished as desired as a result of detonation and the structure was tilted at an angle of 20° (Figure 5(b)) ("Demolition fail", 2014). On December 3, 2017, Pontiac Silverdome Stadium in Michigan, USA, was intended to be demolished by explosives, but the structure remained standing (Figure 5 (c)) ("Detroit Stadı", 2017). On April 4, 2018, a 53-meter-long silo was attempted to be demolished by explosives in Vordingborg, Denmark, but the giant silo was demolished towards the wrong side (Figure 5 (d)) ("Danimarka'da korkutan", 2018). For planning controlled demolition of buildings by explosives in the most accurate way, in other words, in order to avoid such situations or minimize this risk, a demolition simulation program is needed, which includes modern mechanical results and provides the demolition mechanism to be estimated as close to reality as possible.

Figure 5. (a) Toppling of the Power Plant in the wrong direction, (b) Demolition of the structure in the not intended direction, (c) Demolition of the structure in the not intended direction, (d) Toppling of the silo in the wrong direction.

4. CONCLUSION

In this study, demolition techniques have compared with their advantages and disadvantages. Among the techniques discussed, explosive demolition technique stands out with its time and cost advantages. However, the technique with the highest safety risk due to faulty demolitions and dentures is also an explosive demolition technique. There is always a risk of unplanned collapse in demolition work. However, this risk is at maximum level in explosive destruction. In cases where there is not enough space in the demolition site, this risk increases one more time. In this technique, it can be much more complex to correctly predict the direction of destruction. Although there are computer software designed for this purpose, these software increase the cost of the project and using these software requires a new skill. As a continuation of this article, the authors suggest to focus on the studies on demolition simulations. By creating simple but effective demolition models, the level of safety can be brought to upper levels in demolition works.

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