Research paper

Application study of explosive demolition for the wall-slab building

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Abstract

Since the mid-1980s, approximately 4,160,000 apartments have been built in Korea, and more than 70 % of these apartments were high rise apartments having 11 floors or more. Meanwhile, most of the apartments were built in the wall-slab structure, and this kind of wall-slab high rise apartment is a building structure native to Korea of which its demolition cases cannot be found in other countries. Consequently, it can be said that it is absolutely necessary to develop and establish a safe and effective demolition technology in order to prepare for the upcoming time for demolition of wall-slab high rise apartments. The purpose of this manuscript is to introduce cases where the explosive demolition method has been applied on ferroconcrete buildings compounded of the RC structure and the wall-slab structure.

Keywords: Explosive demolition, Wall-slab, Ferroconcrete buildings.

1. Introduction

Since the wall-slab and Rahmen compound structure for 15 floor apartments was first introduced in 1981, most of the high rise apartments built after 1986 have been wall-slab apartments. Compared to the Rahmen-built apartment which has strong supportive force against perpendicular load due to its girder, it is not easy to demolish the wall-slab high rise apartment using mechanical equipment because it does not have a beam. Moreover, whereas it is easy to apply the explosive demolition method on the RC Rahmen structure by blasting the pillar, it is quite difficult to apply the explosive demolition method on the wall-slab structure because of the fact that it can only be demolished by blasting a thin and long perpendicular wall structure. Even technological benchmarking is impossible since this kind of wall-slab structure is a peculiar style of joint housing architecture and can only be found in Korea. There are no precedent cases that can be found around the world where the explosive demolition method has been applied to a pure wall-slab structural building.

Therefore, in order to prepare for future urban high rise apartments demolition, it can be said that it is necessary to develop a safe and practical explosive demolition technology for wall-slab apartments. This application case shown here is about the application of an elementary technique related to the explosive demolition of wall-slab high rise apartments developed through the nation-initiated research task that has been carried out recently on a real structure. From this case, we have confirmed the applicability of the elementary technique and induced the problems and future directions for R&D.

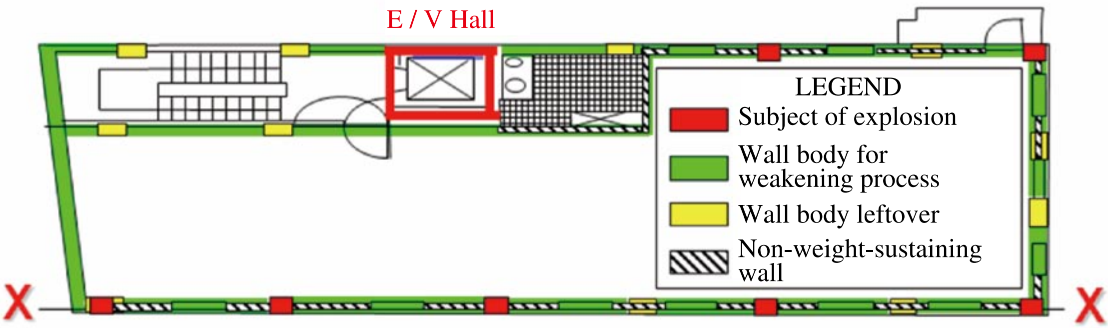
2. Explosive demolition construction

2.1 Summary of the construction

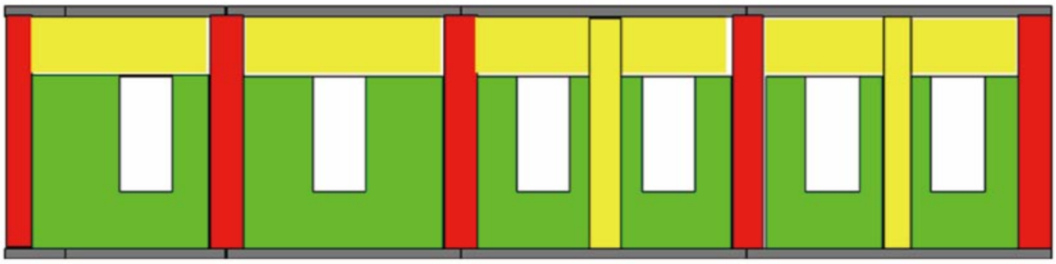
This explosive demolition construction was carried out as an experimental demolition to check out the validity of the explosive demolition of the impediments within the National Hall of Asian Culture building site area. After first having decided that 40 of the buildings within the Hall of Asian Culture building site area, which is estimated to be around 35,000 pyong (= 115,500 m^2), were to be subjected to explosive demolition, the Culture-centered City Development Promotion Planning Committee of the Ministry of Culture and Tourism rejected only 15 buildings after the prior validity test. However, as the National Hall of Asia building site was too close to the center of the city, the Committee decided that it would be difficult to explode the other buildings too, so it eventually decided

Fig. 1 Outside of the building.

Fig. 2 Inside of the building.



(a) Plane view



(b) X–X sectional view

Fig. 3 The range of pre-weakening process and explosive demolition.

to demolish only 2 buildings, the institute building shown here in Fig. 1 and Fig. 2, and another large size building. For the large size building, the Committee made the final decision on whether to demolish it or not after analyzing the influence of the explosive demolition of the institute building over its surrounding environment in terms of noise, vibration, fallout and rupture.

(1) Structure and scale of the building : RC-built + Wall-slab structure, 1 floor underground, 6 floors over-ground, total area 1,413 m^2 approx.

(2) Engineering Method Applied

A. Pre-weakening process : Breaker operation using super-small size equipment and manpower

B. Drilling operation : Insert Drill

C. Blasting operation : Upper part Collapse method

2.2 Present state of operation for each process

(1) Pre-weakening process

The pre-weakening process is carried out for 8 days using 015 B / H, human Breaker and a small-size cutter, and the range of the pre-weakening process is shown in Fig. 3 (a) and (b).

A. Inner walls (pillars and shear walls)

For the independence and stability of the building, wall breaking is performed, leaving the pillars and the shear walls in the form of a pillar because the inside of the building is constituted with a pillar and an inner wall. The sections subjected to the pre-weakening process are classified into the blasting floor and the non-blasting floor, wherein the blasting floors are to be subjected to the blasting by charging explosive. All the blasting floors are subjected to the pre-weakening process.

Fig. 4 Picture of the stairs room after weakening process.

B. Stairs section

The pre-weakening process for the stairs was undertaken as shown in Fig. 4. The inner parts of the stairs were broken using manpower and equipment.

(2) Drilling operation

The drilling operation was carried out for 5 days using leg drill and air compressor. To prevent thin and long wall bodies from being perforated inclined to one side of the wall, special attention was paid to make sure that the drilling was made on the exact center of the wall body.

(3) Protection operation

Protection operation to constrain the splinters of the explosive demolition was carried out for 3 days using long fiber non-woven fabric, diaper wire net, and corrugated iron sheet. For the elevator room where less splinters are produced, only long fiber non-woven fabric and diaper wire net were used for protection. Moreover, protection operation was taken once more from the outside using long fiber non-woven fabric for the parts that were subject to explosive demolition, and to constrain the spurt which occurs on the ground during the building's demolition, non-woven fabric was placed at the grounds around the building.

(4) Water bag installation operation

In order to constrain the dust which occurs during the blasting, vinyl sheet was installed at the 1 F, 3 F and the roof and after making the vinyl water proof, approximately 80 tons of water was filled into it as shown in Fig. 5. Hanhwa, Inc.'s non-electric detonation cap HiNEL Plus and gelatine dynamite MegaMITE 22 mm (D 25 mm × 220 mm × 125 g) were used as the explosives and were loaded at the pillar part. For wall bodies with a thickness of 300 mm, a 10 g m^{-1} explosion inducing line HiCORD Plus 100 was loaded. The total amount of explosives used is listed in Table 1.

(a) Roof (40 ton of water)

(b) 3 F (20 ton of water)

(c) 1 F (20 ton of water)

Fig. 5 Installation of water in the vinyl sheets.

Table 1 Type and quantity of explosives used.

Classifications	Type and Quantity
Explosive	MegaMITE 22 mm 8.384 kg
	HiCORD Plus 100 (10 g m^{-1}) 30 m
Detonation cap	2 Electric detonation caps, 170 HiNEL Plus

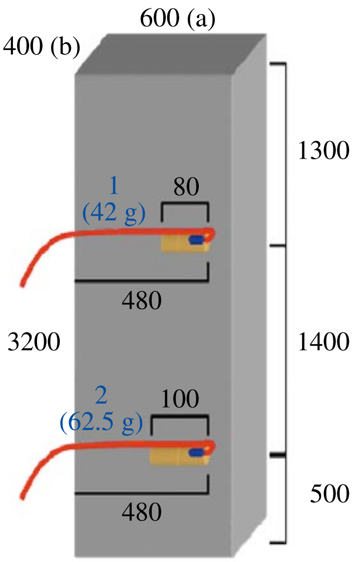


Fig. 6 Charge in pillar.

2.3 Test Blasting

The test blasting to find out the appropriate quantity of charging was carried out as described below.

(1) Summary of the test blasting

A. Date and time of blasting: 2006. 9. 13 14:00

B. Quantity and location of blasting: 1 pillar at 3 F, 1 elevator room at 5 F

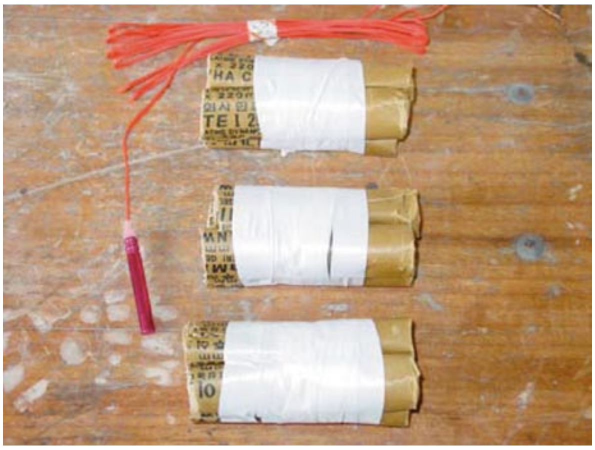
(2) Preparation for blasting

A. Test blasting of pillar part

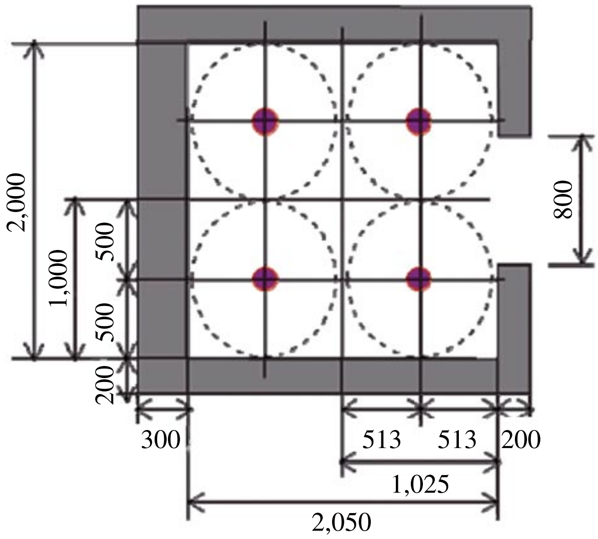
In order to calculate the appropriate quantity of charging to be applied in this blasting, test blasting was carried out on 1 pillar for 2 holes of blasting holes. The patterns of charging dynamite and the specific resources used are shown in Fig. 6.

B. Test blasting of the elevator room

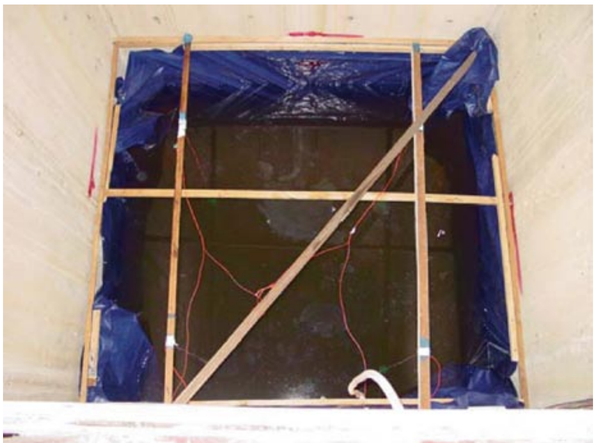
The elevator room is a structural body that plays an important part in terms of structural dynamics, and therefore is called the Core part of the building. The elevator room is constituted by a singular RC wall body except for the exit needed for each floor. The elevator room, similar to the stairs room, which supports the demolition of the building, is not an easy location to carry out the explosion operation during explosive demolition. Meanwhile, it is also a structural body that requires a lot of time and effort in the pre-weakening process. In this test explosion, no pre-weakening process was carried out for the elevator room and instead, the water pressure blasting method was applied to demolish it. By using the water pressure blasting method, the elevator room was exploded by the explosive facilitated in the water that was filled into the elevator room by water proofing process as shown in Fig. 7. This method demolished the elevator room wall body using water by applying the shock wave that is produced while the explosive explodes and the gas pressure increases. As this method uses water, which is not compressive, as the medium, there is less decrease in the shock wave and the gas pressure compared to when the in-air explosion is used,



(a) Explosives



(b) Charge in the elevator room



(c) The elevator room

Fig. 7 Test explosion of the elevator room.

and the effects of constraining the large amount of water spurt during explosion can also be expected. In order to calculate the appropriate amount of explosive to be applied in this blasting, a test blasting was carried out on the 5 F elevator room. The amount of explosive used for the test blasting was calculated according to the explosion coefficient induced from the element test that was carried out before.

Fig. 8 Results of demolition after the test blasting of the pillar part.

(3) Results of the test blasting

A. Pillar part

The results of demolition of the pillar part after blasting are as shown in the Fig. 8. For pattern 1, the results for the upper part of the pillar were very poor. For pattern 2, the results for the lower part of the pillar were a little insufficient. It is estimated that the reason for these results was the strong resistance of the reinforcing rod due to the fact that the intercostals muscles of the central part of the pillar were located in a 30 cm interval which is narrow compared to the general 60 cm interval. For the case of pattern 2, although the demolition effect was not satisfactory, it can be said that it was close to the appropriate amount of explosive because a cumulative effect of 3 blasting holes can be expected in the main blasting.

B. Elevator room

As shown in Fig. 9, the result of the water pressure blasting was poor in each side wall, the wall opposite to the opening part and also in the whole area. Therefore it is estimated that in the main blasting an increase in the amount of explosive is required as in the case of the pillar part.

(a) The left inner wall

(b) The right inner wall

(c) Inside as a whole

Fig. 9 Results of demolition of the elevator room test blasting.

2.4 Main blasting

Since the building subject to blasting was located at the center of the city, the main blasting took place in Saturday morning when the number of traffic and passengers were least.

(1) Summary of the main blasting

A. Date and time of blasting: 10:00 A.M., Sep. 16, 2006

B. Quantity and location of blasting: 21 pillars (66 holes) in 1 F, 2 F, 4 F, 3 elevator rooms

C. Amount of explosive used: 4.259 kg for the pillar, 4.125 kg for the elevator room, total 8.384 kg

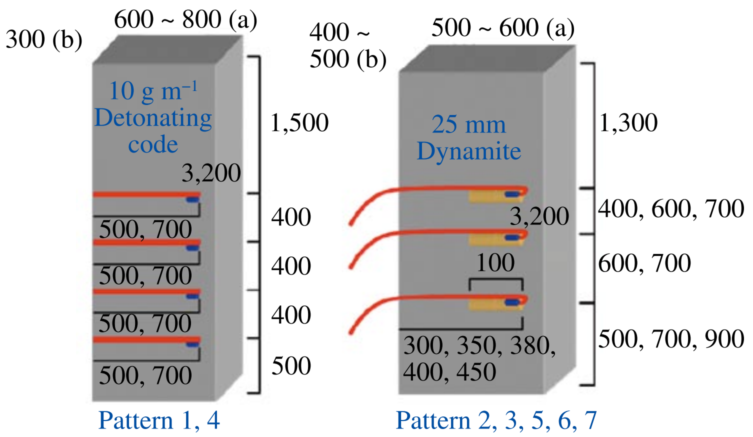


Fig. 10 Specific location of charge in the pillar part.

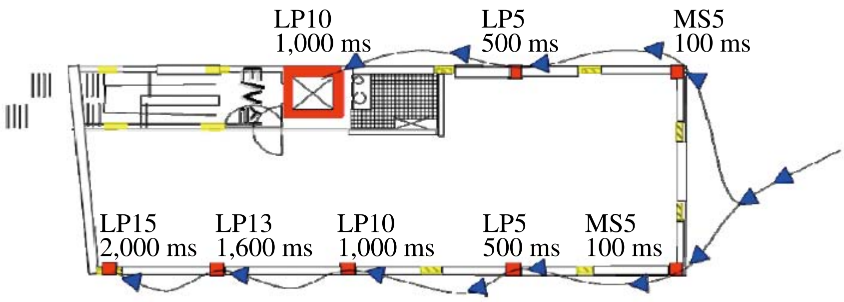


Fig. 11 Detonation cap connections diagram (1F).

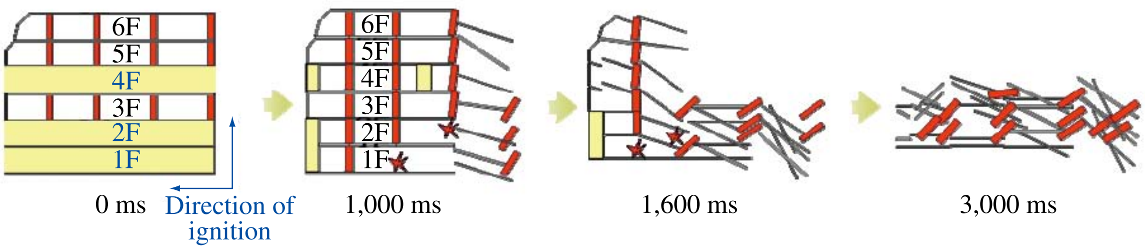


Fig. 12 Pattern of demolition expected.

maximum amount of explosive per delay 0.93 kg / delay, amount of explosive per hole 0.0625 kg / hole Fig. 10 shows the typical explosive location pattern .

Figure 11 shows the 1 F detonation cap line connection, and the demolition pattern which was planned is shown in Fig. 12. The blasting is engineered to start at the right side of the building proceeding to the left side. After the ignition at 1 F, the 2 F and 4 F's ignition is started from the right side proceeding to the left side (same as 1F), after a 500 ms and 1000 ms delay respectively. The time difference of the detonation cap is decided such that the demolition would proceed in the same way as shown in Fig. 12.

(2) Preparation of the main blasting

A. Main blasting of the pillar part

The main blasting of the pillar part was prepared in the same way as the test blasting was prepared.

B. Main blasting of the elevator room by water pressure blasting

Since the demolition result in the test explosion is insufficient, the amount of explosive used in the main blasting is increased in order to induce the total demolition of the elevator room and to avoid any influence on the demolition behavior of the building. Especially, since the demolition results for the wall body opposite to the opening part are insufficient due to the fact that it was 300 mm thick, which is thicker than the side wall, in the main blasting, the location of the dynamite is adjusted to become closer to the wall body opposite the opening part, the amount of dynamite is increased by 62.5 g, and the dynamite locations are dispersed into 4 locations.

(3) Results of the main blasting

The moments of the main blasting are shown in Fig. 13 (a) ~ (d). As shown in the consecutive pictures, the building went down starting from the back part progressing to the front part, from the lower floors to the upper floors because the ignition took place in the order of exploded floor 1 F, 2 F and 4 F.


(a) Before ignition


(b) 500 ms


(c) 3,000 ms


(d) 5,000 ms


(e) Demolition situation of the right side

(f) Demolition situation of the back side


(g) Pillars' demolition


(h) Wall body's demolition

Fig. 13 Pictures of blasting.

The demolition phase after blasting is as shown in Fig. 13 (e) ~ (f). All floors between 1 F and 4 F, including the non-blasting floor 3 F, were totally demolished and only the non-blasting floors above 4 F stayed on top of the leftovers of the demolition. The demolition effect caused by the fall of the floors above 4 F was insignificant. The non-blasting floors which were not subjected to the pre-weakening process remained solid like a singular box due to the fact that this building had a RC and wall-slab compounded structure instead of a pure RC structure. It seems that the demolition of the non-blasting floors is restrained because the leftovers of the demolition of the floors below 4 F functioned as cushions.

Figure 13 (g) ~ (h) shows the demolition phase of the pillar and the wall bodies after the blasting, and as shown in the pictures, it seems that the subjected pillar and the wall bodies were totally demolished by the blasting.

The demolition situation of the elevator room after the blasting is shown in Fig. 14. As shown in this picture, the elevator room was demolished totally without having any influence on the total demolition behavior of the structure.

Fig. 14 Picture after blasting of the elevator room.

3. Concluding remarks

3.1 Test blasting

A. As a result of having done a test blasting with 2 patterns for the amount of dynamite, we were able to confirm the appropriate amount of dynamite required, although there were times when the demolition was insufficient.

B. As a result of having done a test blasting on the elevator room applying the water pressure blasting method, the demolition effect on the inside of the elevator room was insufficient as a whole. Thus, it is estimated that an increase in the amount of dynamite was required in the main blasting.

3.2 Main blasting

A. The building went down starting from the lower floors of the back side of the building, because the ignition took place exactly in the order from 1 F, with the blasting proceeding to 2 F, 4 F, and proceeding from the back side of the building to the front side of the building.

B. The floors between 1 F and 4 F, which includes the non-blasting 3 F, were totally demolished, and the non-blasting floors above 4 F, which had not been subjected to pre-weakening process, were left are remained standing above the demolished floors.

C. The subjected pillar and the wall body were totally demolished, but it seems that a more accurate drilling method for thin wall bodies is required to be developed in the future in order to enhance accuracy in explosive demolition.

D. In the main blasting, there was an increase in the amount of explosive applied for the water pressure blasting of the elevator room, compared to the amount applied in the test blasting. As a result, the elevator room was totally demolished without affecting the demolition behavior of the structure as a whole, but it seems that a supplementary review on the calculation of the appropriate amount of dynamite and the method of dynamite facilitation are required.

Acknowledgement

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References

1. Korea Public Housing Office, Korea Kacoh Inc. (2002), Development of Technology on Explosive Demolition of Wall-slab High Rise Apartments, pp. 1-3.
2. Korea Public Housing Office (2006), Influence Evaluation Report on the Explosive Demolition of Yonhap-Gosi Institute in Gwangju Culture-centered city, pp. 2-27.
3. Korea Public Housing Office (2007), Final Report on the Construction Technology Foundation Establishment Project.

壁式建築物の発破解体に関する応用的研究

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韓国において1980年代半ばより約416万戸のアパートが建設されてきた。このうち約70 %が11階以上の高層ビルであり，そのほとんどが，壁式構造を有している。この壁式構造は変形しにくく，耐震等には不向きであるため，今後立て直しをする必要がある。しかしながら，今まで壁式構造の建設物の発破解体の例はほとんど無く、緊急にその技術を開発確立しなければならない。そこで，本論文では，実際の壁式構造物を用いて，発破解体の実験を行った結果を示したものである。まず，発破解体をする予定の建物で，予備実験を行い，それにより最適装薬量などを検討し，その結果を踏まえてその建物を発破解体したものである。

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