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A Study on the Distribution of the Asbestos Cement Slates and Calculation of Disposal Cost in the Rural Area

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Abstract Asbestos have been used around the world by physical and chemical characteristics that are a reliable and cost-effective. But asbestos, once called the miracle of mineral, is now a quiet time bomb. Asbestos hazards have been studied and the government has pursued 'Comprehensive Measures for Asbestos Management' jointly with related departments. As a part of plan, Ministry of Environment is to introduce legislation 'Asbestos Safety Management Act' through Environment Announcement No. 2010-108. The same Act. 24 shows as follows. Minister of Environment or governor should do survey on the actual condition targeting rural buildings with slates and partly or fully fund to dissolve, remove asbestos slate which was used in each building. However, the local survey was only conducted by each municipality regionally. And there is no actual condition data by area, application and year, and there was no data on disposal costs concerning asbestos slate buildings In this study, discharge of asbestos slate was calculated per unit area and formula was developed with regression analysis. In addition, Demolition, dismantling, disposal costs were computed via a phone survey to disposal companies and then this study proposed standards for this.

Keywords: Asbestos, Asbestos Cement Slate, Rural Area, ACM, Disposal Cost

1. INTRODUCTION

1.1 Background and Purpose

House is like a bowl where people live in so that people can be healthy when the house is healthy[1]. Asbestos cement, which has been used together as the economic development in 1960, is need to be replaced because it may be scattered due to deterioration[2]. Asbestos, once called as the mineral of miracle, is now turning into a time bomb[3]. Especially use of asbestos was banned due to revision of Industrial Safety and Health Law in Feb. 2009, it is urgent to demolish and dissolve asbestos cement slates. In this regard, the government is recommending 'Comprehensive Measures for Asbestos Management' by collaboration with related departments[4] . As a part of such effort, the Ministry of Environment announced legislation of Asbestos Safety Management Act through Notice 2010-108 of Ministry of Environment. The Article 24 of the same act stipulates that the Minister of Environment, Mayor or Governor should examine the current situation on slate farm houses, and support all or part of costs for demolition, removal or disposal of asbestos used for the relevant building. However, only some local governments have performed local examination, and there was no data on actual status of asbestos cement slate building in nationwide farming and fishing village per region, use or construction year, as well as standards for disposal cost. In this light, this study aims to analyze distribution feature of asbestos cement slate in nationwide farming and fishing village, calculate the waste slate disposal cost and present such standards.

1.2 Scope and Method of Study

To calculate disposal cost of waste slates, 103 buildings in 8 myeon-level farming and fishing villages were examined and 7 waste slate disposal companies were selected to calculate generation of asbestos cement slate per unit area as well as formula of disposal cost. To examine distribution feature of asbestos cement slate in farming and fishing village, building ledger of Saewumteo (e-AIS)

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[1] Joo, Dekahn, 「The Social Significance and Improvement Direction for Rural House」, Thesis Collection of Architectural Institute of Korea special issue, 2005

[2] Koo, Jun Mo, 「Removal and Process of Asbestos at Construction site in Korea」, Korea Recycled Construction Resource Institute, 2009

[3] An, Jong joo, et. al(1 person), 「Asbestos Pollution :Silent Time-Bomb」, Nokwon Publisher, 1988

[4] Kim, Young Chan, et. al(3 person), 「A Study on Distribution Feature of Asbestos Cement Slate Roofing of Building in the City」, Thesis Collection of Architectural Institute of Korea, Jan. 2011.

was collected from the Ministry of Land, Transport and Maritime Affairs. A total of 1,979,668 building ledgers in 86 guns were collected(As of Apr. 2010) and asbestos cement slate buildings were analyzed per region, use and construction year. In addition, by summarizing analysis result of building ledger and cost formula, this study calculated the old waste disposal cost in nationwide farming and fishing villages. Fig.1 shows the overall trend of this study.

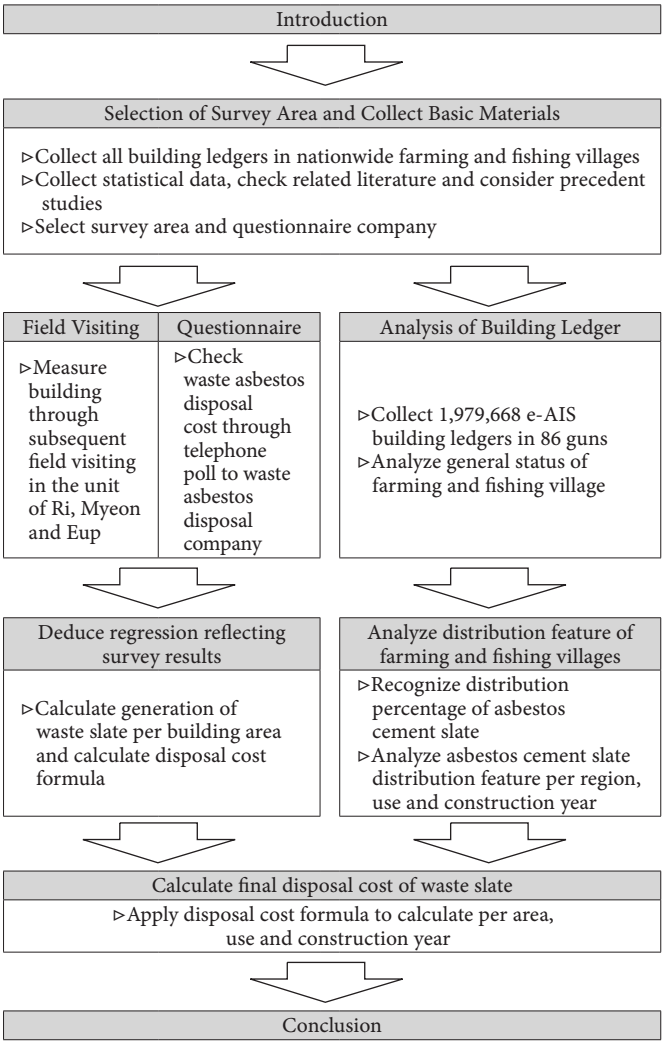


Fig.1. Flowchart of Study

2. THEORETICAL CONSIDERATION

2.1 Overview of Asbestos Cement Slate and Building Register

(1) Overview of Asbestos Cement Slate

Related industries of asbestos cement slate have substantially expanded due to effects of Samaeul campaign since 1960's. Asbestos cements, which main elements are cement and chrysotile is produced by mixing 80~90% of cement with 10~20% of chrysotile(Korea Occupational Safety & Health Agency, 2009)[5]. As time goes by, asbestos fiber in the slate is discharged outside and may cause harmful effects to human and environment[6] With revision of Enforcement Ordinance of Industrial Safety and Health Law in Sep. 2006 in Korea, its production stopped[7]. There was a case that slate house resident got malignant mesothelioma (Jeong, Sun Hee, 2006). There also are cases of studies that quantified the emission of asbestos in the chronical order due to deterioration of slate[8] and studies that estimated the degree of surface corrosion about 0.01~0.024mm/year[9]. The government has been performing some projects related to asbestos cement slate in farming and

Table 1. Government System related to Asbestos Cement Slate (Project ;an of 2010)

Division		Contents of Projects
Farming and Fishing House Environment Project	Farming and Fishing Village Housing Amelioration Project	▹ Lending to deteriorated house improvement in Farming and Fishing Village according to Article 2 of Farming and Fishing Village Reorganization Act(maximum 50 million won per dong) ▹Part of Farming and Fishing Village Housing Environment Amelioration Project
	Empty House Arrangement Project	▹Support demolition or rearrangement of houses in farming and fishing village which have not been used or resided by anyone for 1 year from the date when residence or use was checked with the mayor, governor or head of gu office(1 million won per dong) ▹Part of Farming and Fishing Village Housing Environment Amelioration Project
Hope Labor Project	Farming and Fishing Village Slate Roof Improvement Project	▹Aid to roof improvement after removal of slates to improve residence welfare and to remove asbestos, 16.8 billion won to 2,000 households(support about 8.4 million won per village) ▹Promotion committee of self governing body selects the beneficiary among those who receive basic living subsidies or low-incomes

[5] Paek Do Myung, et. al (8 persons), 「Prevalence of Asbestosis in Korean Asbestos Industry」, Korean Society of Occupational & Environmental Medicine, Vol. 7, No. 1, 1995

[6] Bornemann P, Hildebrandt U. 「On the problem of environmental pollution by weathering products of asbestos cement.」 Staub Reinhalt. Luft, 1986

[7] The Ministry of Environment, 「Asbestos Management Catalogue」, 2009

[8] Kim Hyeon Wook et. al(5 persons), 「Releasing of asbestos fibers from the weathered asbestos cement slate roofing」, Journal of Korean Society of Occupational and Environmental Hygiene. Vol. 20, No. 2, 2010

[9] Spurny KR, 「On the release of asbestos fibers from weathered and corroded asbestos cement products.」 Environmental Research, 1989

fishing villages, but those efforts are not sufficient and there is no actual data on distribution of asbestos cement slate per building percentage, region, and use or construction year.

There are 2 types of slates such as natural slate and asbestos cement slate. In Korea, asbestos cement slate had been mainly used up to Sep. 2006. Following table 1[4]shows the system related to asbestos cement slate, and table 2[4)11)] shows general matters of asbestos cement slate produced in Korea.

Table 2. General Specification of Asbestos Cement Slate

Specification		Width (cm)	Length (cm)	Area (m^2)	Weight per Unit Area (kg/m^2)	Contents of asbestos
Small type	No. 6	720	1,820	1.3104	10.5kg	10%
	No. 7	720	2,120	1.5266		
	No. 8	720	2,420	1.7424		
Big Type	No. 6	960	1,820	1.7472		
	No. 7	960	2,120	2.0352		
	No. 8	960	2,420	2.3232		

(2) Overview of Building Register

Building register was specified in Article 38•39 of Building Act and Article 25 of enforcement ordinance of the same act. In addition, it is specified in details in 'Rules on Indication and Management of Building Ledger'. Administration materials related to building include building ledger, taxation article and illegal building management ledger and the building ledger is the basis of construction information[10]. It is suitable for analyzing the construction year and nationwide use status of slate roof materials since the building ledger contains basic information of land area, building area, total floor area, building-to-land ratio, roof materials, construction year and use. Since it only contains data on buildings legally approved, there are some missing information on illegal buildings[11].

2.2 Definition of Farming and Fishing Village

Farming and fishing village is the area notified by the Ministry of Food, Agriculture, Forestry and Fisheries in consideration of agricultural and fishing industry, industries related to agriculture and fishery, farming and fishing population and living circumstances in the region among A. Eup, Myeon region, B. Other regions in addition to A[12]. Class B is not specified in the enforcement ordinance or rule of the same act. Accordingly, gun-unit administrative district was included in this study as it corresponded to farming and fishing village including eup and myeon. Gun-unit administrative districts in metropolitan city were also included. Eup and myeon area in the administration district of city unit were excluded as they were considered to correspond to peripheral region of the city. In this regard, this study defined gun-unit administrative district of Busan metropolitan city, Daegu metropolitan city and Ulsan metropolitan city all gun-unit administrative districts in 8 provinces throughout the country.

2.3 Consideration on Precedent Study

Among recent studies on asbestos slate in addition to the studies on harmfulness of asbestos, Jeong, Da Wi et. al(9 person)[13] analyzed the contents of asbestos and distribution rate of asbestos cement slate for a total of 981 houses in the unit of villages by separating 1,230,000 national farming families into 5 major areas. Kim, Young Chan et. al (2 persons[4)]) examined real conditions of use of asbestos cement slate as well as awareness of residents with 41,860 buildings at 9 myeong, 8 provinces throughout the country as well as 610 residents. And Kim, Hyeon Wook et. al(5 persons[8)]) randomly selected 2 buildings built in 1960's, 1970's and 1980's

Table 3. Consideration of Domestic Precedent Studies Related

Division	Study Results
Jeong, Da Wi et. al (2009)	▷In 1,667 slate samples, asbestos was detected in 1,665 samples. About 88% have materials suspicious of having asbestos and amosite was detected in some samples. ▷About 38% of farm building are found to have slate roofs. ▷Confirmed that asbestos cement slate roofs are most widely used in farming and fishing villages up to now.
Kim, Young Chan et. al (2009)	▷As a result of analysis by field survey, the percentage of asbestos cement slate building in farming and fishing village is found to be 35.41% ▷Identified that asbestos cement slate buildings have taken about 61.25% by 1970's. ▷Majority of residents of farming and fishing village were found to have high level of recognition on government policy waste asbestos management, asbestos, slate and waste slate disposal method.
Kim Hyeon Wook et. al (2009)	▷As a result of checking asbestos with SEM/EDXA, the density of fiber discharged was in the range of 7,152f/L~ 31,202f/L ▷It was found out that asbestos cement slate has increased fiber discharge with longer service life and higher rainfalls. ▷Second pollution is expected, which is scattered to the air again after evaporation of rainfall. ▷Emphasize necessity of ultimate removal as well as management actions such as over-painting and sealing depending on degree of damage

[10] Kim, Jeong-ok et. al(3 person), 「An Efficient Update for Attribute Data of the Digital Map using Building Registers : Focused on Building Numbers of the New Address」, Korean Society of Surveying Geodesy, Journal of Photogrammetry and Cartography, Vol. 26, No. 3, 2008

[11] Kim, Young Chan, et. al(3 person), 「A Study on Distribution Feature of Asbestos Cement Slate Roofing of Building in the City」, Thesis Collection of Architectural Institute of Korea, Jan. 2011.

[12] Article 3(5) of Framework Act on Agriculture and Fishery·Farming and Fishing Village and Food Industry

[13] Jeong, Da Wi et. al, 「A Study on Calculation of Generation of Waste Asbestos of Farming Houses Building」, Thesis Collection of Korea Society of Waste Management, 2009

respectively, and analyzed the discharge of asbestos fiber from deterioration of slate roof using polarizing microscope and phase-contrast microscope. Table 3 shows the results of each study.

However, there is a limit in such studies in that the number of samples were few and the results were obtained through sample survey so that it would be difficult to generalize buildings of asbestos cement slate which are widely distributed in farming and fishing village. In this regard, this study analyzed the buildings of all farming and fishing villages throughout the country per region, use and construction year and calculated disposal costs for each cases.

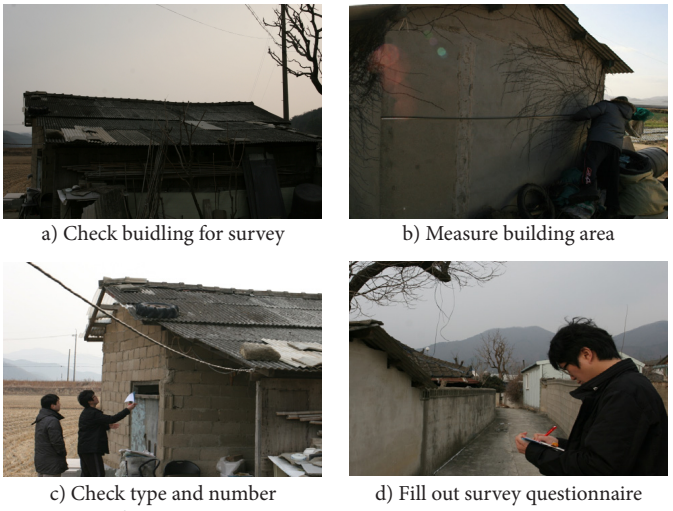
3. SURVEY OVERVIEW AND CALCULATION OF FORMULA

3.1 Overview of Survey Areas and Survey Methods

To calculate the generation of asbestos cement slate per unit area in a total of 103 buildings at 8 myeon-unit farming and fishing villages in 8 provinces throughout the country, 2 or 3-person investigator team visited the sites in the unit of ri, myeon and eup through subsequent visiting and performed actual measurement. Contents of survey include location of land, building area, use of building, structure, roof material, roof type(gambrel roof, hipped roof, hip-and-gable roof), eaves expansion, eaves expansion area, type of slate and number of slate. Building area was calculated using general area calculation method through ruler and laser measuring instrument in comparison with building ledger, and the experimental value was first applied. Area of asbestos cement slate used for roof materials was calculated by multiplying the number of slates in reference to slate specification if, for example, 60 sheets of small type slates for house No. 9 were used so that it was calculated to be 1.7424×60m^2(see table 2). Present status of survey area was as shown in the table 4. Fig. 2 shows photos of actual measurement through field visiting.

Table 4. Present Status of Survey Area

Division		Number of buildings	Remarks
Gyeonggi-do	a yeon, A gun	16	Farming houses
Gangwon-do	b myeon, B city	11	Farming houses
Chungcheokbuk-do	c myeon, C gun	15	Farming houses
Chungcheonnam-do	d myeon, D city	10	Fishermen's house
Jeonlabuk-do	e myeon, E city	9	Farming houses
Jeonlanam-do	f myeon, F city	13	Fishermen's house
Gyeongsangbuk-do	g myeon, G city	18	Farming houses
Gyeongsangnam-do	h myeon, H city	11	Farming houses
Total		103	



a) Check buidling for survey b) Measure building area

c) Check type and number of aggregates d) Fill out survey questionnaire

Fig.2. Actual Measurement Survey through Field Visiting

3.2 Overview and Result of Questionnaire

Nationwide 7 waste asbestos disposal companies were given with questionnaires to calculate the final disposal costs of asbestos cement slate. It was divided into demolition•dismantling cost, transportation cost and reclamation cost, and included costs for demolition, dismantling cost of pure slate, spraying of chemicals preventing scattering, cost of double-pole and horizontal scaffolding outside building, wearing of protective mask and consumable materials and mobilization of cranes. Table 5 shows the costs for demolition, dismantling, transportation and reclamation of asbestos cement slate including details.

Table 5. Cost of Demolition, Dismantling, Transportation and Reclamation

Division		Cost	Remarks
Demolition·dismantling	max	30,000 won/m^2	25,000 won per m^2 on average while it differs depending on company
	min	20,000 won/m^2	
Transportation	mean	20,000 won/t	600,000 won per 30t on average while it differs depending on distance from the company
Reclamation	max	270,000 won/t	255,000 won per t on average while it differs depending on company
	min	240,000 won/t	

3.3 Calculation of Formula for Calculation of Disposal Cost

Regression analysis was performed to calculate the generation of asbestos cement slate per building area through field survey on 103 buildings throughout the country. Here, the area of building is calculated by width x length of outer wall of building and the floor area is expressed as the area of asbestos cement slate. As a result of analysis, roof area of asbestos cement slate per building area including the type of gambrel roof, hipped roof and hip-and-gable roof was found to be as shown in Fig. 3. The formula generally used to calculate roof area in building area is building area×(1.3~1.6) as used in the commercial company. It includes the loss in terms of execution, and excludes eaves expansion, duplication of width and length(about 1.16 times) due to feature of slate execution. Accordingly, this field survey was conducted as it requires the formula of roof area per building area of slate only.

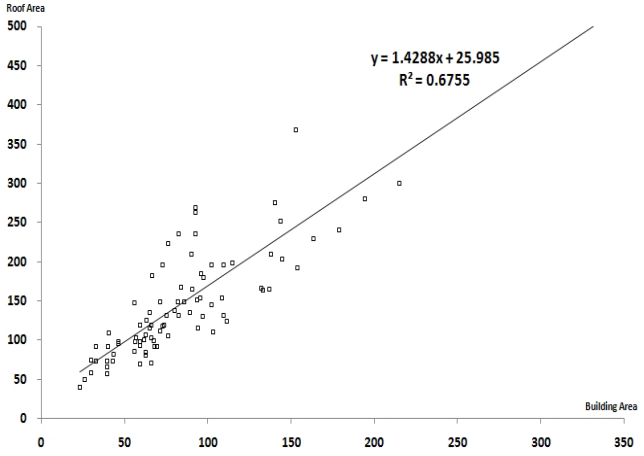


Fig. 3. Roof Area of Asbestos Cement Slate per Building Area (Unit : m^2)

Weight of asbestos cement slate per unit area is generally 10.5kg(See table 2). Accordingly, formula(1) was obtained by combining the generation of asbestos cement slate of asbestos cement slate building per unit area with regression formula in Fig. 3. In addition, by reflecting the results of questionnaire, we converted ton unit to kg unit, and calculated the costs of demolition, dismantling, transportation and reclamation of asbestos cement slate as shown in the following formula (2), (3), (4) and expressed the total disposal cost as shown in the formula (5).

$$\text{Slate Emission(kg)} = (1.428\times S_A+25.98)\times 10.5 \quad \text{---------- (1)}$$

$$\text{CostD} = (1.428\times S_A+25.98)\times 25{,}000 \quad \text{---------- (2)}$$

$$\text{CostT} = (1.428\times S_A+25.98)\times 10.5\times 20 \quad \text{---------- (3)}$$

$$\text{CostL} = (1.428\times S_A+25.98)\times 10.5\times 255 \quad \text{---------- (4)}$$

$$\underline{\text{Slate disposal cost(₩)} = \text{Cost}_D+\text{Cost}_T+\text{Cost}_L} \\ \underline{= 27887.5\times(1.428\times S_A+25.98)} \quad \text{------ (5)}$$

Where, SA : building area(m^2)
$Cost_D$: cost of demolition and dismantling of asbestos cement slate(₩)
$Cost_T$: waste slate transportation cost(₩)
$Cost_L$: waste slate reclamation cost(₩)

4. DISTRIBUTION FEATURE OF ASBESTOS CEMENT SLATE IN FARMING AND FISHING VILLAGE AND CALCULATION OF DISPOSAL COST

4.1 General Status of Farming and Fishing Village

Total number of buildings in nationwide 86 guns classified as farming and fishing village was 1,979,668 and total building area was found to be 269,113,734m^2. To examine percentage of buildings in farming and fishing village per use, the use of 28 buildings indicated in Article 2 (2) of Building Act. was classified into the house, factory, warehouse, stable, other facilities and not-indicated. As a result of analysis, the percentage of house was highest with 66.98% in terms of number of buildings, and 33.08% in terms of building area. To examine the percentage of buildings at farming and fishing village per construction year, buildings before 1960's to 2000's were classified in chronicle order and analyzed. The percentage of buildings of which construction year was not indicated was 12.40%, percentage of building area, 6.11%. As a result of analysis except non-indicated values, the period before 1960's was highest with 27.17% in terms of number of buildings,

Table 6. Present Status of Target Areas

Region	Total	Gun Status
Busan	1	Gijan-gun
Daegu	1	Dalseong-gun
Incheon	2	Ganghwa-gun, Ongjin-gun
Ulsan	1	Wulju-gun
Gyeoinggi	4	Gapyeong-gun, Yangpyeong-gun, Yeoju-gun, Yeoncheon-gun
Gangwon	11	Hongcheon-gun, Hoengsong-gun, Youngwol-gun, Pyeongchang-gun, Jeongseon-gun, Cheolwon-gun, Hwacheon-gun, Yanggu-gun, Inje-gun, Goseong-gun, Yangyang-gun
Chungbuk	9	Cheongwon-gun, Boeun-gun, Okcheon-gun, Youngdong-gun, Jeongpyeong-gun, Jicheon-gun, Goesan-gun, Eumseong-gun, Danyang-gun
Chungnam	9	Keumsan-gun, Dangjin-gun, Buyeo-gun, Seocheon-gun, Yeongi-gun, Yeosan-gun, Cheongyang-gun, Taean-gun, Hongseong-gun
Jeonbuk	8	Wanju-gun, Jinan-gun, Muju-gun, Jangsu-gun, Imsil-gun, Sunchang-gun, Gochang-gun, Buan-gun
Jeonnam	17	Damyang-gun, Kokseong-gun, Gure-gun, Goheung-gun, Boseong-gun, Hwasun-gun, Jangheung-gun, Gangjin-gun, Haenam-gun, Youngnam-gun, Muan-gun, Hampyeong-gun, Youngkwang-gun, Jangseong-gun, Wando-gun, Jindo-gun, Shinan-gun
Gyeongbuk	13	Gunwi-dun, Uiseong-gun, Cheongsong-gun, Youngyang-gun, Youngdeok-gun, Cheongdo-gun, Koryong-gun, Seongju-gun, Chilgok-gun, Yeocheon-gun, Bonghwa-gun, Uljin-gun, Ulleung-gun
Gyeongnam	10	Geochang-gun, Goseong-gun, Namhae-gun, Sancheong-gun, Uiryeong-gun, Changnyeong-gun, Hadong-gun, Haman-gun, Hamyang-gun, Hapcheon-gun
Total	86	Total number of buildings: 1,979,668 Total building area : 269,113,734m^2

and 1990's was highest with 39.62% in terms of building areas. Fig. 6 shows present status of target areas, Table 7 shows the percentage per use and Fig. 4 shows the percentage of building per construction year.

Table 7. Present Status of Buildings at Farming and Fishing Village per Use

Division	Houses	Factory	Warehouse	Stale	Others	Not Indicated
Per Number	66.98%	2.92%	6.42%	6.83%	15.82%	1.04%
Per Area	33.08%	21.83%	5.88%	15.31%	22.73%	1.17%

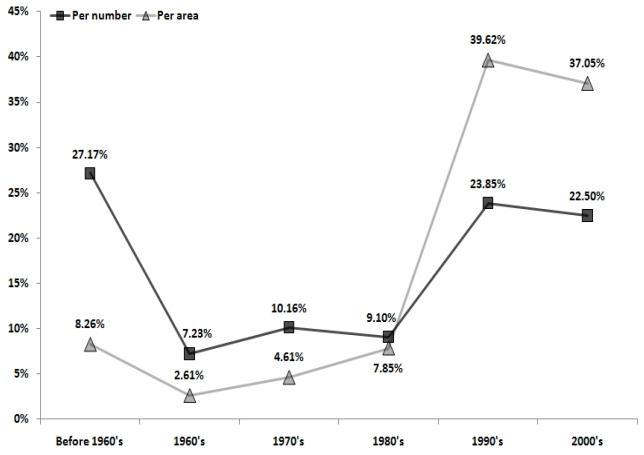


Fig. 4. Percentage of Buildings at Farming and Fishing Village per Construction Year

To examine the percentage of asbestos cement slate building in farming and fishing village, we classified roof materials indicated in building ledger into slates, (reinforced) concrete, roof tile and not indicated. Among them, the number of buildings that use slate as roofing was a total of 573,506 buildings and its building area was 45,432,404m^2. Accordingly, the percentage of asbestos cement slate in farming and fishing village was 28.97% in terms of number of buildings and 19.88% in terms of building area. Present status of buildings at farming and fishing village per roof materials is as shown in the Table 8.

Table 8. Present Status of Buildings at Farming and Fishing Village per Roofing

Division	Slate	(Reinforced) Concrete	Roof Tile	Other roof	Not Indicated
Per Number	28.97%	24.73%	18.76%	25.56%	1.98%
Per Area	16.88%	29.66%	7.32%	41.72%	4.42%

4.2 Percentage of Asbestos Cement Slate per Region, Construction Year and Use

(1) Percentage of Asbestos Cement Slate per Region

We examined the percentage of asbestos cement slate in farming and fishing village per region. In terms of number of building, Ganghwa-gun, Incheon metropolitan city recorded highest with 31.17% among metropolitan areas. Among ordinary provinces, Jeonlabuk-do recorded highest percentage with 34.65%, followed by Jeonlanam-do with 33.59% and Gyeongsangnam-do with 32.98%, and Gyeongsangbuk-do with 31.01%. In terms of building area, Dalseong-gun, Daegu metropolitan city recorded highest with 18.95% among metropolitan areas and among ordinary provinces, Gyeonggi-do recorded highest percentage with 25.61%, while Gijang-gun, metropolitan city showed lowest with 1.67% and Chungcheokbuk-do with 10.18%. In all areas, the area of percentage was found to be lower than the percentage of numbers, which seems to be attributable to the fact that building with asbestos cement slate has smaller areas than ordinary building. Busan metropolitan city was found to have biggest difference in percentage. Fig. 5 shows the percentage of asbestos cement slate building in nationwide farming and fishing village per areas.

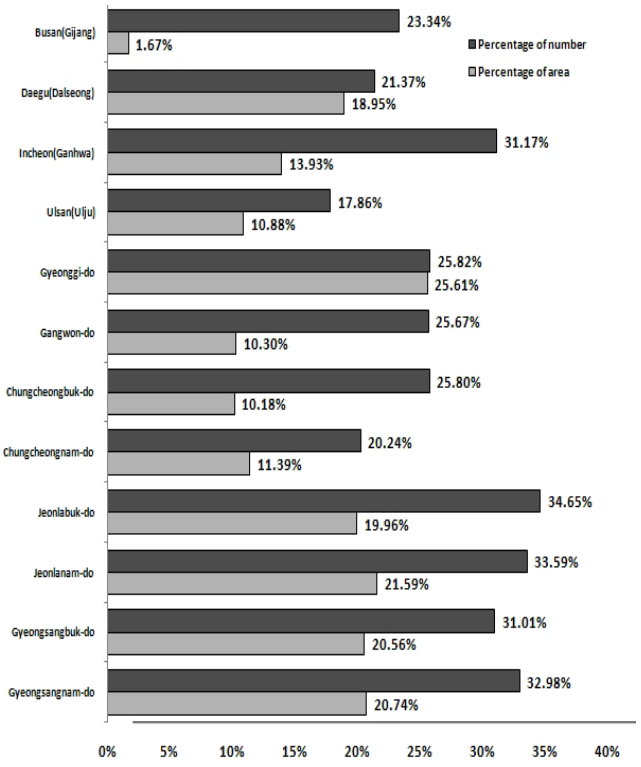


Fig. 5. Percentage of Asbestos Cement Slate in Farming and Fishing village per Area

(2) Percentage of Asbestos Cement Slate by Construction Year

We classified the percentage of asbestos cement slate building in farming and fishing village for each period from before 1960's to 200's. The number of buildings with construction year not indicated took 17.50% and building area took 9.81%. In terms of the percentage of asbestos cement slate building except those not indicated, those before 1960's were highest with 44.98% in terms of number of building. In terms of building area, 1990's was highest

with 47.99%. What is remarkable was the fact that they are decrease trend in terms of number of building, while it was increase trend gradually up to 1990's. In addition, it was found out that the building of asbestos cement slate became bigger in 1990's. Fig. 6 shows the percentage of asbestos cement slate building in farming and fishing villages per construction year except those not indicated.

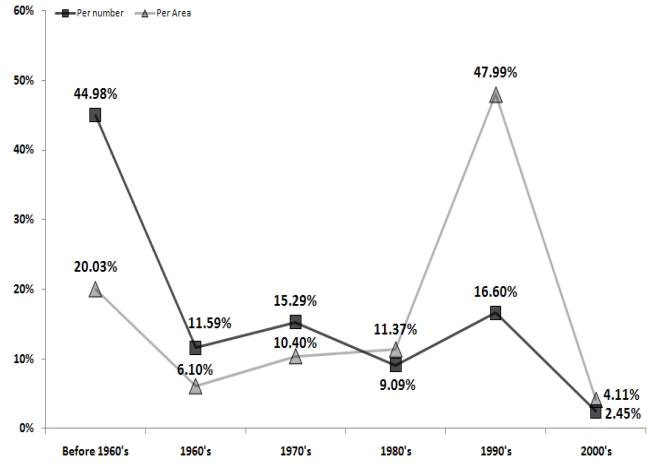


Fig. 6. Percentage of Asbestos Cement Slate in Farming and Fishing Village per Construction Year

(3) Percentage of Asbestos Cement Slate by Use

To examine the percentage of asbestos cement slate in farming and fishing village per use, we classified use of building into house, factory, warehouse, stale, other facilities and those not indicated and analyzed them. The number of buildings with use not indicated was 0.81% and building area was 1.41%. As a result of analysis except those not indicated, house recorded highest with 73.02% in terms of number of house and 36.45% in terms of building area. In particular, the stale was found to record over-whelmingly high percentage of areas than that of numbers, which seems to be attributable to the fact that asbestos cement slate was used in bulk to sale Fig. 7 shows the percentage of asbestos cement slate in farming and fishing village per use except those not indicated.

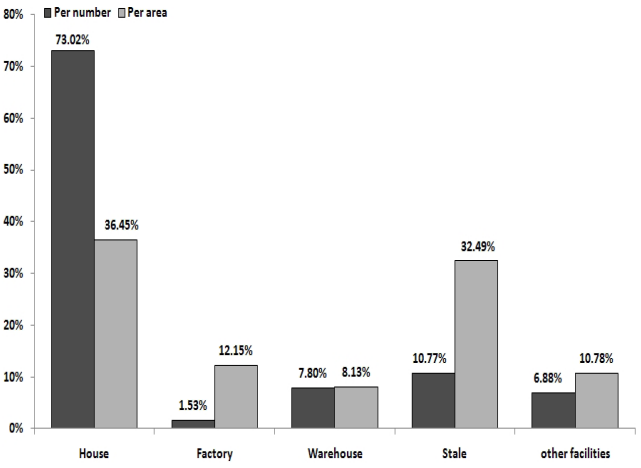


Fig. 7. Percentage of Asbestos Cement Slate in Farming and Fishing Village per Use

4.3 Distribution Feature of Asbestos Cement Slate in Farming and Fishing Village per Construction Year within Use

To examine distribution feature of farming and fishing village asbestos cement slate building, we classified them per use, and then per construction year, and analyzed them in terms of number and building areas. While building before 1960's recorded 57.22% in terms of number and 50.53% in terms of areas, in case of house, and then showed gradually decrease trend. In case of non-houses, buildings of 199's were found to take highest percentage in terms of number and area. In particular, the percentage of 1990's was 65.71% for stale and 41.25% for factory in terms of number, while it was 80.23% and 61.42%, respectively in terms of area, showing that they are used in bulk and concentrated in 1990's. With regard to Fig., highest quantity of asbestos cement slate was used in 1990's in all buildings including house and the cause is attributable to massive use of asbestos cement slate by non-house building. In particular, given the fact that thatched roof slate roof improvement project led by government from 1971 to 1976[14] was not reflected in the date of approval in building ledger, most houses are asbestos cement slate building before 1970's. However, since distribution of asbestos cement slate between house and non-house building per construction year shows clear difference, it should be considered in government measure to demolish or dismantle such building. Fig. 8 shows the present status of asbestos cement slate building per construction year per use in terms of number of farming and fishing villages, while Fig. 9 shows present status in terms of areas.

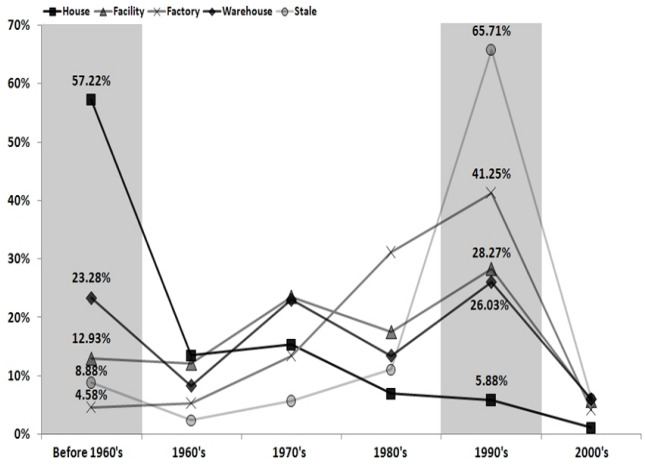


Fig. 8. Present Status of Construction Year of Asbestos Cement Slate Building per Use(in terms of number)

4.4 Calculation of Disposal Cost of Asbestos Cement Slate

We combined results of field measurement, results of questionnaire and analysis result of building ledger and calculated disposal cost of asbestos cement slate per region, use or construction year. To calculate the disposal cost of asbestos cement slate per region, we obtained the building area of asbestos cement slate per region, and calculated using following formula and applied formula(5). To dispose all asbestos cement slates in farming and

[14] Saemaeul Campaign Institute, 「10 Year History of Saemaeul Campaign」, Ministry of Internal Affairs, 1980

Table 9. Disposal Cost of Asbestos Cement Slate per Use and per Construction Year (Unit : m^2, 10,000 won)

Division	House		Factory		Warehouse		Stale		Other Facilities	
	building area	Disposal Cost	building area	Disposal Cost	building area	Disposal Cost	building area	Disposal Cost	building area	Disposal Cost
Before 1960's	7,120,992	28,358,247	54,713	217,956	293,420	1,168,571	469,308	1,869,013	241,200	960,613
1960's	1,783,001	7,100,580	92,183	367,176	148,356	590,874	92,832	369,762	365,324	1,454,916
1970's	2,213,867	8,816,432	271,212	1,080,130	841,195	3,349,994	330,880	1,317,748	568,090	2,262,399
1980's	1,129,577	4,498,426	1,454,184	5,791,120	402,261	1,602,010	934,571	3,721,849	669,601	2,666,646
1990's	1,565,759	6,235,449	3,206,740	12,770,386	1,258,819	5,013,110	11,017,659	43,876,080	2,208,348	8,794,452
2000's	279,947	1,114,914	142,093	565,935	172,625	687,524	886,563	3,530,663	188,549	750,936
Not indicated	2,233,971	8,896,492	219,620	874,672	523,145	2,083,409	821,498	3,271,553	588,974	2,345,565
Total	16,327,113	65,020,540	5,440,745	21,667,375	3,639,821	14,495,493	14,553,311	57,956,669	4,830,086	19,235,528

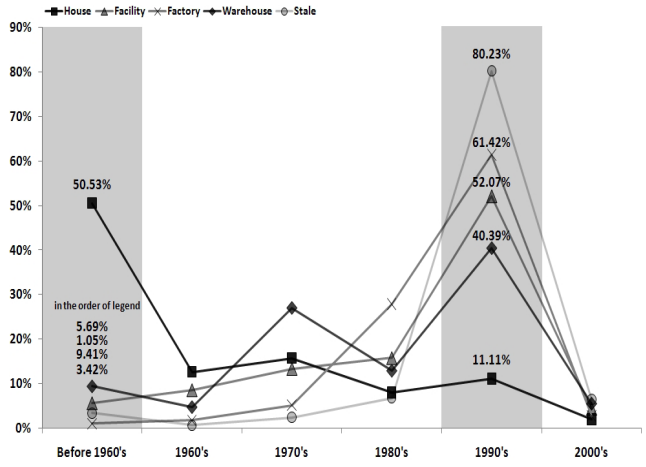


Fig. 9. Present Status of Construction Year of Asbestos Cement Slate Building per Use(in terms of area)

Table 10. Disposal Cost of Asbestos Cement Slate per Region

Region	Building Area (Unit: m^2)	Disposal Cost (Unit: 10,000 won)
Busan(Gijang)	98,567	392,600
Daegu(Dalseong)	862,072	3,433,131
Incheon(Ganghwa)	473,536	1,885,850
Ulsan(Ulju)	1,628,393	6,484,880
Gyeonggi-do	4,776,291	19,020,865
Gangwon-do	1,984,431	7,902,741
Chungcheokbuk-do	3,362,509	13,390,708
Chungcheonnam-do	3,897,071	15,519,516
Jeonlabuk-do	3,720,017	14,814,426
Jeonlanam-do	13,026,754	51,876,972
Gyeongsangbuk-do	5,951,137	23,699,495
Gyeongsangnam-do	5,651,626	22,506,740
Total	45,432,404	180,927,924

fishing village, about 1 trillion and 809.3 billion won are required. Since Gijang-gun, Busan metropolitan city recorded lowest building area of asbestos cement slate with 98,567m^2, its disposal cost was lowest with about 3.9 billion won. Jeonlanam-do recorded highest building area of asbestos cement slate with 13,026,754m^2 and highest disposal cost of about 518.8 billion won. Table 10 shows the building area and disposal cost of asbestos cement slate per region.

We calculated disposal cost of asbestos cement slate per use and construction year. Building area of which construction use was not indicated was 641.328m^2 and disposal cost was calculated to be about 25.5 billion won. As house recorded highest building area of 16,327,113m^2 and its disposal cost was also highest at about 650.2 billion won. Along with this, the sale took high percentage of building area with 14,553,331m^2 and disposal cost of about 579.5 billion. In terms of construction year, 1990's recorded highest area with 19,663,941m^2 and disposal cost of 783 billion won (including those not indicated). Table 9 shows disposal cost of asbestos cement slate per use and construction year of farming and fishing village.

5. CONCLUSION

This study was conducted with field survey of 103 buildings in 8 provinces to calculate the generation of asbestos cement slate and telephone polls on 7 final waste asbestos disposal companies. In addition, we analyzed all building ledgers of Ministry of Land, Transport and Maritime Affairs Saewumteo(e-AIS), targeting all gun-unit administrative districts and calculated final disposal cost of waste asbestos. Following are the results of the study.

First, as a result of field visiting on 103 buildings in national provinces to calculate the generation of asbestos cement slate per unit area, the generation of asbestos cement slate per unit area was as shown in formula (1). Results of telephone poll targeting 7 waste asbestos final treatment companies are as shown in formula (2), (3), (4). By combining the results of field survey and those of telephone polls, final disposal cost formula (5) of asbestos cement slate was obtained.

Second, as a result of analyzing 1,979,668 building ledgers of Ministry of Land, Transport and Maritime Affairs Saewumteo(e-AIS) in 86 guns throughout the country, the total number of asbestos cement slate building in farming and fishing village was found to be 573,506 and total building area was 45,432,404m^2. It took 28.97% in terms of number of buildings and 19.88% in terms of building area. With regard to percentage of asbestos cement slate building per region, Jeonlabuk-do recorded highest with 34.65%, Gyeonggi-do recorded highest with 25.61% in terms of building

area.

Third, buildings before 1960's recorded highest with 44.98% in terms of number of building, and those in 1990's recorded highest with 47.99% in terms of building area. In terms of use, house recorded highest with 73.02% in terms of number of building and also highest with 36.45% in terms of building area.

Fourth, it was found that there was difference between the percentage distributions of house and non-house asbestos cement slate per construction year. Buildings before 1960's were highest among houses and those in 1990's were highest among non-houses. Accordingly, it should be considered in future government policy and legislation related to demolition and dismantling of asbestos cement slate in farming and fishing villages.

Fifth, total disposal cost of asbestos cement slate in the farming and fishing village was expected to be about 1 trillion and 809.3 billion won. Per region, Jeonlanam-do recorded highest building rate of asbestos cement slate with 13,026,754m^2 and highest disposal cost of about 518.8 billion won. In terms of use, house recorded highest area distribution with 16,327,113m^2, followed by stales of 14,553,311m^2. Disposal cost was found to be about 650.2 billion won and 579.6 billion won. In terms of construction year, those built in 1990's recorded highest area 78,308,837m^2 and highest disposal cost of 783 billion won.

Distribution feature of asbestos cement slate in farming and fishing village drawn as a result of this study is expected to be of great help in preparation of comprehensive plan and supports related to demolition and dismantling focusing on farming and fishing village in the future. In addition, it is also expected to contribute much preliminary investigation and establishment of work plan for demolition and dismantling of asbestos cement slate with development of formula that can calculate generation of asbestos cement slate and disposal cost based on building area. Accordingly, it can be used as a preliminary data for development of integrated asbestos management system for proper disposal and database of asbestos cement slate buildings included in future study plan.

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