Abstract
In recent years more and more houses of the low- and middle-income group in Indonesia have reportedly been affected by earthquakes. These houses are mostly non-engineered because most of them are designed and constructed without the involvement of professional engineers or architects. Clarifying the construction process of these non-engineered houses is the key to improving their seismic resilience.

In this article, the authors examined how non-engineered houses are constructed in Jakarta. Most of the data used in this study is based on questionnaire surveys in two residential areas. After clarifying the background of the two surveyed areas and physical characteristics of non-engineered houses there, the authors examined how non-engineered housing construction is implemented through the analyses of construction scale, types of informally organized construction sectors and the relationship between homeowners and the sectors. The results indicate that non-engineered construction varies in scale and technological level depending on the type of construction sector, and offer basic knowledge that leads to further study for improving the seismic resilience of non-engineered houses.

Keywords: non-engineered; housing construction; Jakarta; field investigation

1. Introduction
1.1 Background and Objective
It has been reported in recent years, that houses of low- and middle-income groups in Indonesia have problems regarding vulnerability to earthquake (Kawase et al. 2007). Most of the houses are called non-engineered houses because they are constructed by people without the intervention of professional engineers (Arya et al., 1986). While in the index of earthquake risk developed by UNEP/UNISDR (2011) Indonesia ranks at a very high level of seismic risk, there are reportedly a great number of non-engineered houses in Jakarta (Struyk, 1990). In this article, non-engineered housing construction is defined as housing construction implemented via self-help or by informally organized construction sectors (abbreviated as informal construction sectors) and a non-engineered house is defined as a house built with non-engineered construction.

International organizations have implemented projects to increase public awareness regarding building safety in Indonesia. JICA (2011) helped the government develop building construction laws and administration systems. UNCRD (2004) organized community-based approaches, which worked well in raising awareness of disaster risk. However, most of these activities were likely implemented only in regions which have already experienced disasters. Measures to improve seismic resilience have not been taken adequately in Jakarta.

Aiming at improving the seismic resilience of houses, some studies on the structural performance of building elements have been carried out (Narafu et al., 2009; Imai et al., 2009). However variability of construction accuracy, depending on the worker, is also a problem. Narafu (2009) found that accuracy in construction practice is a greater issue than the quality of local materials.

Thus, there are factors that contribute to poor accuracy in the construction process. However, little is known about non-engineered housing construction, especially in Jakarta. Understanding the construction process of non-engineered housing can offer basic knowledge to examine what steps should be taken for the improvement of seismic resilience of houses.

The objective of this study is to examine how non-engineered houses are constructed based on a field investigation in Jakarta. It focused on the scale of
construction, types of informal construction sectors and relationship between homeowners and the sectors concerning projects.

1.2 Outline

Before analyzing the construction process, the authors collected background information on the surveyed areas and physical aspects of non-engineered construction (Fig.1.). Chapter 2 shows the characteristics of the two surveyed areas based on a previous study and household condition survey. Chapter 3 clarifies typical construction methods that are employed there through an exterior survey. Chapter 4 shows what construction process is actually adopted in non-engineered housing based on the results of construction samples and detailed interviews. Chapter 5 sums up the conclusion of this article with suggestions on how the findings could contribute to improving the seismic resilience of houses.

1.3 Method

The following research was carried out for this study. First, as preliminary research the authors reviewed literature relevant to non-engineered housing construction and conducted interviews with experts on current construction policy. Second, they conducted a field investigation in two residential areas (Ps Manggis and Uljami) in Jakarta (Fig.2.). The investigation consisted of a questionnaire survey, an exterior survey and detailed interviews as explained below.

Questionnaire Survey: The authors conducted questionnaire surveys of residents in the areas concerning household condition, material used in their buildings and housing construction they have carried out.

Exterior survey: This survey aimed at understanding what physical characteristics including materials, structural type and building scale, conventional houses have in the areas. The authors wrote down each building's characteristics on a common survey sheet.

Detailed Interview: The authors conducted detailed interviews on housing construction with several participants chosen from sample respondents to the questionnaire survey.

Table 1. presents the attributes and samples of the two areas.

| Surveyed Area | Ps Manggis | Uljami |
|---------------|------------|--------|
| Sub district  | Setia Budhi| Pesanggrahan |
| Urban Type    | Central    | Suburban |
| Sample        | Exterior survey | 104 buildings | 95 buildings |
| Questionnaire | 74 households | 51 households |
| Detailed interview | 2 projects | 2 projects |

2. Background Information of Surveyed Areas

Ps Manggis is a residential area with well-maintained roads, situated close to the downtown area in Jakarta (Fig.3.). The area has had its infrastructure, such as roads and sewage canals, upgraded through national government funding because of the greater economic significance of the people who reside there. Uljami is also a residential area situated in a suburban region 10 km southwest of the central area (Fig.4.). The region surrounding and including Uljami up until the 1960s was a Betawi settlement and was developed by public funding in the 1970s, resulting in more people moving to this area. Actually the area, which originally belonged to West Java Province, was incorporated into DKI Jakarta (Special Capital City District of Jakarta) in 1975.

Fig.3. Photo and Surveyed Area of Ps Manggis

Fig.4. Photo and Surveyed Area of Uljami

Fig.5. shows the development trend from the 1970s to 2009 of Setia Budhi and Pesanggrahan in terms of the total area developed by sectors (Shima, 2010). Setia Budhi greatly exceeded Pesanggrahan for the entire period reaching a peak in the period from 1975 to 1979. In Pesanggrahan the area of developed land
reached a peak in the period from 1990 to 1994. To sum up, Uljami can be viewed as a suburban residential area by reason of the transfer of provinces from West Java to DKI Jakarta and the development trend after 1990. On the other hand, Ps Manggis can be viewed as a central residential area based on the fact that the area already had been developed during the 1970s.

2.2 Condition of Household

The authors collected information on various household attributes. Basic results for the two areas are shown in Table 2. The results of several household attributes are described below.

(1) Household Income

Household income is considered to be a determining factor in the quality of housing, especially in developing countries. Mean monthly incomes of Ps Manggis and Uljami are 3.7 juta and 2.5 juta respectively. However, median incomes in both areas are included from 1.0 to 2.5 juta, and most of the households (96% in both areas) have incomes of 10 juta or less per month. These results indicate that most of the inhabitants in the two areas are low- or middle-income people.

(2) Initial Year of Occupancy

Knowing when a building was built is an important factor in knowing how a residential area developed. Fig.6 shows the number of households occupied as a function of time. The trend for Ps Manggis increases from the 1940s to the 1960s. After this, it shows a decline through the 80s. Starting in the 1990s, the number of households increased again and after 2000 about 25 new households (38% of 72) came into this area. In contrast, the number of households in Uljami has increased since the 1960s. Especially, the number of households established in the 1990s was double the number of households established in the 1980s. The rapid increase in the 1990s is in agreement with the development trend of Pesanggrahan shown in Fig.4.

(3) Dwelling Status

All household heads are divided into secure owners and room or house renters. Table 3. shows the relationship between dwelling status and initial years of occupancy. About 80% of secure owners came before 2000. On the other hand, 24 out of 29 renters (83%) came after 2000. Especially, 13 out of 15 rental households in Uljami were established after 2000.

Through an analysis of the histories of development and household conditions, the two surveyed areas can be viewed as different models of residential area: Ps Manggis for a central residential area and Uljami for a suburban one, while most respondents in both areas belong to the low- and middle-income class.

3. Physical Characteristics of Constructions

3.1 Material

In Indonesia, masonry construction is common for home building. Through the field survey, the authors found three types of masonry house units: brick, bataco (concrete block) and hebel (Table 4.). Bricks have been traditionally used in most types of buildings, including residences and public and religious buildings, since the beginning of Dutch colonization in the 17th century. Bataco is a masonry material composed of cement and sand similar to concrete block. It is reported that this material started to be used when the domestic cement industry developed rather dramatically in the 1970s (Kobayashi, 2006). Hebel is a kind of lightweight concrete block developed in Germany. According to a staff member in a home center in Jakarta, Hebel is mostly used as wall material in middle-rise and high-rise buildings and has become popular in house construction in recent years.
masonry type and roofing used in the respondent's house. The relationship between the kind of masonry material employed and the year of construction for current houses is presented in Table 5. While bricks have been used since before 1960, the use of bataco started in the 1980s. A peak in houses built with bataco occurred in the 1980s.

The authors attempt to obtain a quantitative grasp of house characteristics based on the results of their exterior survey. Fig.7. presents the percentages of buildings by kinds of masonry material and roofing materials in Ps Manggis and Uljami. Considering masonry material, buildings with brick walls (65% of 40 buildings) make up a larger proportion of the buildings than buildings with bataco walls (27%) in Ps Manggis. In contrast, there are fewer buildings with brick walls (22%) than buildings with bataco (65%). As for roofing material however, there is not much difference between the two areas. Over 55% of the buildings used tile, with asbestos the next most popular in both areas.

### Table 4. Masonry Materials Commonly Used in Jakarta

| Masonry Material | Brick | Bataco (Concrete block) | Hebel (Lightweight concrete block) |
|------------------|-------|-------------------------|-----------------------------------|
| Photo            |       |                         |                                   |
| SGL              | 1.5   | 2.3                     | 0.5                               |
| Thickness (mm)   |       |                         |                                   |
| bricks           | 25cm×12.5×5 | 40cm×20×10 | 60cm×20×10 |
| Price per 1000   | Rp.320→400 | Rp.1,300→1,400 | Rp.6,200→7,500 |
| Pieces and price for a wall (1m²) | 65-70 pieces | Rp.25,600 | 12 pieces | Rp.16,700 | 8 pieces | Rp.60,000 |

### Table 5. Masonry Materials and Years of Construction

| Masonry Material | 1960 ~89 | 1960 ~89 | 1980 ~89 | 1960 ~89 | 2000 ~10 | Total |
|------------------|----------|----------|----------|----------|----------|-------|
| BATACO           | 0        | 0        | 2        | 7        | 3        | 12    |
| BRICK            | 1        | 1        | 1        | 1        | 1        | 1     |
| BOTH             | 0        | 0        | 1        | 2        | 1        | 4     |
| Total            | 1        | 2        | 5        | 10       | 5        | 32    |

### Table 6. Conventional Structural System

| Structural System | CM (Confined Masonry) | RC+infill (RC frame+in-filled wall) |
|-------------------|------------------------|------------------------------------|
| Construction      | 1) Build masonry wall | 1) Cast concrete confine wall with frames |
|                   | 2) Cast concrete      |                                    |
|                   |                       |                                     |

The authors made a further analysis of exterior survey data to break construction down into three types as shown in Table 7. First, the subsample used in this analysis consists of houses of which the three characteristics (number of stories, structural system and masonry material) are known (n=72) and divided into each surveyed area (Ps Manggis: n₁=27, Uljami: n₂=45). Second, the authors tried to extract most combinations of all characteristics except roofing material from each sample. For Uljami, one-storied buildings of CM construction with bataco walls make up 49% of 45 buildings and can be considered as typical construction for Uljami. The authors note that Ps Manggis has much more variety in construction. Two-storied buildings of RC+infill construction with brick walls is the most common type (33% of 15 buildings) among two-storied buildings in the area, while in contrast this type of construction was found to be the least popular in Uljami. Therefore, this type of construction is unique to Ps Manggis and can be recognized as the typical construction in this area. One-storied buildings of CM constructions with brick walls make up the largest ratio (6 out of 10 buildings) in Ps Manggis. Moreover, this construction type was found to be the second most common in Uljami. This means that this construction type is common practice in both areas and can be called medium type between Uljami and Ps Manggis.

Through the analysis stated above, the authors extracted three typical constructions: one-storied building of CM with bataco walls, one-storied building of CM with brick walls and two-storied building of RC+infill with brick walls. As stated above, Ps Manggis and Uljami can be considered as models of an urban residential area and a suburban model.
respectively. So the authors call the three types of construction method: Suburban type, Medium type and Urban type respectively (Table 7.).

Table 7. Types of Construction Method

| Suburban Type | Medium Type | Urban Type |
|---------------|-------------|------------|
| 1 storied     | 1 storied   | 2 storied  |
| CM            | CM          | RC+infill  |
| Bataco        | Brick       | Brick      |

4. Construction Process

In the questionnaire survey, the authors collected information concerning the housing construction process, and obtained 106 samples (Uljami 42, Ps Manggis 64) of housing construction from 99 responding households. In addition, they conducted interviews with four households regarding the details of their housing construction.

4.1 Overview of Constructions

All the construction samples ranged from roofing repairs to new building construction. In order to examine how current housing construction is implemented, the authors focused on 73 constructions carried out after 1990 (69% of 106 constructions), and in addition classified these constructions into two groups in terms of scale: new building (25 constructions) and renovations (58 constructions). Renovation constructions included many types of construction such as extension of rooms or additional stories or roof repairs. Actually, roofing is the most common type (25% of 72 constructions), followed by extensions of rooms or additional stories (19%). In this country, roofs and ceilings deteriorate easily due to intense rainfall. Fig.8. shows housing constructions by construction year in Ps Manggis and Uljami.

4.2 Construction Team

Who built a house could be a significant factor to examine concerning the seismic building resistance of the dwelling. Housing constructions are characterized by types of construction head, defined as a head or leader of a construction team who supervises the housing construction either in whole or part. There are four types of construction heads in terms of sector as shown in Table 8. Except 14 constructions by uncertain builders, 90 constructions were determined to be non-engineered ones, which were implemented via self-help or by formally organized construction sectors and two constructions were found to be engineered ones, which were implemented by contractors.

Fig.9. shows types of construction heads in both areas. In Ps Manggis 20 constructions (40% of 50) are classified as either mandor or contractor. On the other hand, 18 constructions were built via self-help. For Uljami 12 constructions (57% of 21) are classified as mandor, and 6 (29%) were performed by a homeowner himself. Therefore there is not much difference between Ps Manggis and Uljami concerning type of construction head.

The selection of construction heads may depend on the scale of construction. Fig.10. shows constructions by types of construction heads for new buildings and renovations. Twelve out of 18 new building constructions were classified as mandor. As for renovation, construction via self-help accounts for the largest proportion (45% of 51 constructions) followed by construction by mandor (37%). To sum up, the authors found differences of types of construction heads between new building and renovation. This indicates that the scale of construction may affect the selection of construction heads. For renovation
constructions, a mandor (mean 27.2 juta) is more costly than self-help (mean 15 juta). Thus, a mandor is expected to provide a better quality construction service than self-help for renovation.

4.3 Order System

The order system represents the financial relationship between homeowners and construction sectors or workers. The authors obtained information in the questionnaire survey concerning how owners paid labor charges and how they obtained building materials for a construction project. Based on the survey, construction projects in Jakarta can be classified into four patterns. Payments for labor by an owner were made in two ways: paying labor charge in a lump-sum to a construction head (Head type) or paying wages to each construction worker (Each type). The mechanism of purchasing materials is also divided into two types: a construction head or worker purchasing (Set type) and a homeowner purchasing by himself (Self type).

Table 9. Patterns of Order Systems

| Construction Heads | Building Materials Purchased by | | |
|--------------------|---------------------------------|---|---|
| Head-Set           | Head-Self                        | 5 | 3 |
| Head-Set           | Head-Self                        | 5 | 12|
| Each-Set           | Each-Self                        | 4 | 2 |
| Each-Set           | Each-Self                        | 2 | 2 |
| Each-Self          | Each-Self                        | 6 | 1 |
| Each-Self          | Each-Self                        | 5 | 2 |
| Each-Self          | Each-Self                        | 0 | 3 |
| Each-Self          | Each-Self                        | 1 | 11|

Fig. 11. Distribution of Constructions in Order System Patterns

In the usual case of a general contractor’s project, for example, what homeowners do is simply pay money to contractors. This type of construction would belong to the Head-Set type. On the other hand, when an owner builds a house in a more primitive way, by collecting material for himself and paying wages to individual helpers, this case would belong to the Each-Self type. Overall, in this type of construction homeowners are required to have greater ability to manage the construction and they carry more risk concerning defects than the other three types. This means that in the Head-Set type the construction head carries more risk and gains more credibility for their performance than in the other types. Of course, a project can include different order systems. But in the questionnaire the respondents were asked to choose the system most likely to include their construction experience.

4.4 Matrix for Patterns of Order System

A subsample of constructions is distributed in a matrix according to patterns of order systems. Distributions of patterns of the system for the four subsamples (Ps Manggis: n=35, Uljami: n=14, Mandor: n=26, Self Help+Tukang kayu: n=21) are presented in Fig. 11. Each subsample is divided into two groups: new building and renovation. Comparing the matrices between Ps Manggis and Uljami, the two matrices for new building construction show similar distributions. However, in the matrices for renovation constructions in Ps Manggis the Each-Self type makes up a larger proportion (48% of 25 constructions) than Uljami (2 out of 5 constructions). For mandor and self help+tukang kayu, there are clearer contrasts in the distributions in the matrices. Constructions by mandors belonging to the Head-Set type account for the largest proportion (42% of 26 constructions), while for self help+tukang kayu Each-Self type makes up the largest proportion (71% of 21 constructions). This is true for renovation constructions in general.

In addition, among constructions by mandor there are differences between new building and renovation. Nine out of 11 new building constructions are included in Head type. On the other hand, 11 out of 14 renovation constructions are included in Set type. This result indicates that the scale of construction influences the patterns of order systems. In the case...
of new building, the material cost is larger than for renovation. Thus, if an owner puts more responsibility on a mandor, he will not have to worry about being deceived regarding the cost of materials because he authorises the mandor to obtain materials. Conversely, if he assigns less responsibility, he has to purchase materials himself. In renovation, labor charges are larger compared to material costs. A homeowners' decision as to whether to pay in a lump-sum or to each member directly depends upon how much trust the homeowner has in the mandor.

### 4.5 Case Studies of Constructions

The authors conducted detailed interviews with four householders concerning further information on housing construction. Table 10. shows several attributes of the four cases. Homeowner No. 1 constructed a house for his own family with the assistance of his friends from his hometown. He chose to construct via self-help. He had experience in working on construction sites and was familiar with construction. The building was constructed of CM without finishing on internal and external walls. He has a plan for extensions after obtaining sufficient budget for it.

No. 2 is a case where a mandor was involved. The householder engaged the mandor, who was one of his father's acquaintances. So she had great trust in his performance. Actually, she has asked him to repair her roof several times so far. In addition, the authors found another three constructions by him among the questionnaire samples from Uljami. The mandor is likely considered as reliable in the Uljami area.

Construction No. 3 is also a mandor's project. The reason for asking the mandor was that the homeowner and mandor were in a very friendly relationship. However, it was the homeowner that determined what materials to purchase based on the proposal for material selection given by the mandor. Then the mandor went to purchase the building materials. In this way, he could not cheat in handling the money. According to the owner, mandors take less responsibility for deceit or defect than contractors because of a lack of formal contract. He therefore did not ask the mandor to purchase materials without ensuring a detailed statement of them.

Also in home construction No. 4, a mandor was involved. He was one of the owner's relatives who works as a mandor. The owner employed him only as a helper in the construction. As the order system was classified as Each-Self, he drew a plan, organized a construction team including the mandor and went to purchase building materials at a shop near his home. However he received the material list that the mandor had made before going to the material shop. Although he was not involved in management of the team and cost, he helped the owner make better choices concerning building materials. This is also a case where a mandor did not handle the whole of the construction process.

Through the analysis stated above in this chapter, the authors obtained information about current housing construction for low or middle-income people. First, most of the constructions were carried out by self-help or informal sectors including tukang kayu and mandor. Most new building constructions were built by mandors or through self-help. Second, mandors were recognized as the more reliable construction sector among low- and middle-income people. In some cases of constructions by mandors, they had the responsibility for the whole construction process including spending for labor and procuring building materials. The monthly income of households who ordered new building constructions through a mandor ranged from 1.0 juta to 10 juta.

### 5. Conclusion

This article examined the process of non-engineered housing constructions in Jakarta based on the results of a field investigation. The important findings and conclusions are stated below.

Although most of the respondents of each area belong to the low- and middle-income class, the surveyed areas are of different types of residential area (Ps Manggis for the central residential area and Uljami for the suburban one) based on the histories of development and the results of the household condition surveys.

Through exterior surveys, three types of construction methods were commonly implemented among low- and middle-income people: defined as Suburban, Medium and Urban types. In particular, as masonry materials bricks are more often used in Ps Manggis, while in Uljami the majority of houses were constructed of bataco. This difference is likely associated with the year of construction. In suburban areas like Uljami where developments mostly started after the 1980s, bataco is commonly used among low- and middle-income people.

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Table 10. Four Case Studies of Construction Projects

| Household No. | Surveyed Area | Monthly Income (juta) | Year | Total Cost (juta) | Type | Construction Head | Order System |
|---------------|---------------|-----------------------|------|------------------|------|-------------------|-------------|
| 1             | Uljami        | 10                    | 2010 | 10               | New Building | Self             | Each-Self   |
| 2             | Uljami        | 1                      | 1990 | 45               | New Building | Mandor           | Head-Set    |
| 3             | Ps Manggis    | 15                    | 1995 | 15               | Renovation   | Mandor           | Head-Set    |
| 4             | Ps Manggis    | 60                    | 2010 | 60               | New Building | Each-Self        |             |

1juta =1,000,000 Rp = 110 USD (Sep. 2011)
The authors examined how non-engineered housing constructions are implemented based on the construction samples and detailed interviews. The majority of houses built after 1990 are shown to have been built by non-engineered construction, which is classified into three types according to who served as the construction head: self-help, tukang kayu (carpenter) and mandor (organizer). All these types are more likely associated with scale of construction than the urban types.

Most new building constructions are likely built through self-help or by mandors. The analysis of patterns of order systems demonstrates how mandors take much more responsibility for fraud or defects than other types of non-engineered construction. In addition, mandors are likely influential in the selection of building materials as shown in the case studies.

Indeed, mandors are not licensed as well as tukang kayu. However they can be recognized as more reliable sectors among local people due to their greater responsibility concerning order systems. Actually they are involved in more new building constructions than any other type of construction sector. Therefore they can be expected to serve as an advisor, raising public awareness regarding earthquake safety by helping owners make better choices of materials or techniques, as shown in the case of construction No. 4.

Although this study does not evaluate how resistant to earthquakes the non-engineered houses are, it offers basic information concerning such housing. The results of construction method types can be expected to be used for seismic risk evaluation and hazard maps. In addition, a systematic and enhanced understanding of the variability of construction accuracy could be obtained by comparing it with the different types of informal sectors that are clarified in this article.

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Notes
1 According to Arya et al. (1986), “the term non-engineered building may only be vaguely defined as buildings which are spontaneously and informally constructed in the traditional manner without intervention by qualified architects and engineers in their design” (p.2). In this paper, the term non-engineered construction is used in the sense of construction which is implemented via the self-help approach or informal sectors.

2 According to Struyk (1990), houses developed by individual households make up 85% of annual housing production in Indonesia. The production is conducted with assistance provided by family, friends and informal sector labor and has approximately the same meaning as non-engineered construction in this paper. Although this evidence is not based on current data, it indicates that non-engineered houses are the majority of current housing production.

3 Based on an interview with the head of RW, which is a small administration community, in Uljami. Betawi is a local ethnic group who have lived around Jakarta from about the 17th century.

4 DKI Jakarta is the abbreviated name of Daerah Khusus Ibukota Jakarta, which means Special Capital City District of Jakarta. In this article, Jakarta corresponds to DKI Jakarta.

5 The World Bank defined income classification of countries with a Gross National Income per capita. Countries with a GNI from $3,976 to $12,276 belong to the upper-middle-income economies. This definition was used as a reference in examining income classification in Indonesia. In this paper, the authors considered a household with 10 juta ($1,100) or less monthly income as low- and middle-income people.

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