Changes in the unit price of work for reinforced concrete construction based on building sites

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Abstract. The unit price of work is the price required to complete each unit of quantity of work that consists of the unit price for the wage of labour, materials, and equipment used. Changes in unit prices are possibly determined by the different sites in which a building is constructed. For budget planners or construction executors, a good understanding of the changes in the unit price of work is required to identify the reasonable amount of budget needed. Given these circumstances, this study was conducted to analyse and identify the pattern of changes in the unit price of work based on the locations of a building in the Province of Aceh. This research focuses on the unit price of reinforced concrete work for the building structure components, as the work that has the most significant proportion of cost in building construction. The pattern of change is described in the form of price indexes by applying the price in Banda Aceh City as a reference for other cities/districts. The analysis results in two patterns of the unit price index, which is below or above of the reference index. This condition follows the pattern of the unit price of materials and wages. The ease of access to a region also determine the changes in the price index.

1. Introduction
The accuracy of each estimate is determined mainly by how much project information has been obtained at each stage of the project. Some previous studies suggest that estimation accuracy may be influenced by the availability of adequate information relating to design documents, historical data on previous construction project prices, accuracy and reliability of cost information [1]. A good understanding of the scope of works and the availability of sufficient project information will provide more accurate estimation results [2] [3].

The change and accuracy of estimation values on a particular type of building can also be influenced by the project location factor [4]. Location factors are needed to adjust the whole element of project costs from a defined scope of construction work based on one geographical location to another geographic location. This factor accommodates differences in productivity and labour costs, equipment, materials, distribution, duties, taxes, procurement processes, technical/design aspects, and project administration [5]. Estimating the price of a building needs to consider the geographically differentiated location conditions by setting a factor adjustment to make the estimation value generated more rationally [6]. Location factor considerations in the estimation process are often associated with the exchange rate

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and time factors due to the difference in the cost of building a construction project when implemented at different times and locations [7]. Geographically, construction costs may vary due to distance variations of project sites and suppliers, climatic and weather conditions, and market conditions. Construction built in the city centre can have variations in price when compared to constructions built on the remote area. In general, the further the location of a construction project, the more expensive it will cost to transport materials, labour, equipment to the job site.

Cost estimation at the conceptual stage are prepared to provide preliminary information on budget requirements for a type of construction and at the same time act as a justificatory to declare the project can be continued or not continued. This requirement encourages the process of developing some estimation methods involving location factors to be more accurate, flexible, manageable, and rapidly updated. A number of studies have developed various estimation methods using locations as variables, such as in studies related to location cost adjustment factors [6-9], development of the construction cost index [10, 11] or related to the development of cost models [12, 13].

The process of estimating the price of a building can use a variety of methods according to the stages of the project cycle or adjust to the needs of an estimate. One of the commonly used estimation methods is to use estimates based on the unit price (UP) of work. The unit price of work is the unit of price used to estimate the value of a work based on the amount of material, labour wage, and equipment used. In most construction works in Indonesia; unit prices have been established through SNI standards or other guidelines issued by the relevant technical institutions. For example, Indonesian National Standard SNI 7394: 2008 on the procedures for calculating the unit price of concrete work for the construction of buildings and housing [14] and the Ministry of Public Work Regulation No. 26/PRT/M/2016 on the unit price analysis of work for public services work. [15].

The Province of Aceh consists of several cities and districts with varying geographic and distance conditions from the capital of Banda Aceh. This difference in itself affects the difference in material prices, labour wages, and equipment costs. Furthermore, the unit price of work is also affected due to the difference in prices. This study was conducted to analyse and identify changes that occur in the unit price of construction works by using a price index based on the location aspect of construction. This research is focused on the structural components of reinforced concrete in building construction. The selection of structural components of a building caused by this component has the highest proportion of cost compared to other building components.

2. Methods

2.1. Object and data collection
This study uses the object price of the work unit for the structural components of a building. The component of the structure is a reinforced concrete construction with work components consisting of concrete, reinforcement, and formwork. The study area consists of 23 cities and districts within Aceh Province.

The data used in this study is secondary data in the form of basic price for the material, labour, and equipment for the year 2018 issued by the Governor of Aceh [16]. Requirements for each work related to the object of research using SNI standard [14] and Minister of Public Works Regulation [15].

2.2. Analysis
This research begins by identifying the type of material, labour, and equipment needed for each work. The identification process is done by referring to the requirement of each unit price of work. Data on material, labour and equipment prices that have been collected in advance are grouped for 23 regions and three types of reinforced concrete work.

Analysis of unit price of work (UP) for each type of work (i) and region (j) is done by summing the cost for material (M), labour (L), and overhead/profit (OP) as shown in equation 2.1.
\[ U_P_{ij} = \sum (M + L + OP) \] (1)

The UP used in this study can be distinguished by the work components of reinforced concrete and the structural components of the building. The UP for the components of work consisted of 4 UPs for concrete work, 2 UPs for reinforcement work, and 5 UPs for formwork. The UP for building structural components consisted of the construction of the foundation, tie beams, columns, beam, and slab. The list of UP standards used is shown in Table 1.

| UP for reinforced concrete work components [15] | UP for building structures components [14] |
|-----------------------------------------------|------------------------------------------|
| Concrete (per m³)                             |                                          |
| Anl. No. A.4.1.1.7 (\(f'c = 19.3\) MPa)       | Anl. No. A.4.1.1.20 (for foundation)     |
| Anl. No. A.4.1.1.8 (\(f'c = 21.7\) MPa)       | Anl. No. A.4.1.1.21 (for tie beam)       |
| Anl. No. A.4.1.1.9 (\(f'c = 24.0\) MPa)       | Anl. No. A.4.1.1.22 (for column)         |
| Anl. No. A.4.1.1.10 (\(f'c = 26.4\) MPa)      | Anl. No. A.4.1.1.23 (for beam)           |
| Reinforcement (per 10 kg)                     |                                          |
| Anl. No. A.4.1.1.17a (plain bar)              | Anl. No. 6.28 (for foundation)           |
| Anl. No. A.4.1.1.17b (deformed bar)           | Anl. No. A.4.1.1.21 (for tie beam)       |
| Formwork (per m²)                             |                                          |
| Anl. No. A.4.1.1.20 (for foundation)          | Anl. No. 6.29 (for 1 m³ tie beam)        |
| Anl. No. A.4.1.1.21 (for tie beam)            | Anl. No. 6.30 (for 1 m³ column)          |
| Anl. No. A.4.1.1.22 (for column)              | Anl. No. 6.31 (for 1 m³ beam)            |
| Anl. No. A.4.1.1.23 (for beam)                | Anl. No. 6.32 (for 1 m³ slab)            |
| Anl. No. A.4.1.1.24 (for slab)                |                                          |

The unit price index is analysed by setting a price for Banda Aceh City as the reference price for other regions with a value of 1.000. Changes in the index occurring in a region \(U_P I_i\) resulted from comparing the price difference in the observed region \(C_i\) and prices in reference city of Banda Aceh \(C_{BA}\). The price index is calculated by equation 2.2.

\[ Unit \ Price \ Index \ (U_P I_i) = \frac{C_i}{C_{BA}} \] (2)

3. Results and discussions

3.1. The unit price of work

The reinforced concrete work unit prices are grouped based on the work components and structural components of a building. The price component of each reinforced concrete work consists of material prices, labour wages, and overhead/profit. The standard used the assumption of work is accomplished by using no mechanical equipment, or only using simple working tools. The results of UP analysis are shown in Table 2.

The unit price for concrete works appearances consistent with the highest prices appearing in Simeulue District, a district located on an island separated from the mainland of Sumatra island. The lowest price occurred in Aceh Tamiang District, a district located on the border with North Sumatra Province. The extent of unit price disparity for both areas reached 40%. For reinforcement and formwork, the highest and lowest work unit prices tend to vary across districts. The highest price disparity that occurs is 44.7% for reinforcement work and 39.7% for formwork work.
The unit price standard of building structural components combines the use of concrete, reinforcement, and formwork in one analysis at a time. The analysis is expressed in a cubic metre (m$^3$) unit of concrete for each structural component with the specified number of reinforcement uses. The use of reinforcement for structural components is 150 kg for the foundation, 200 kg for the tie beam, 300 kg for the column, 200 kg for the beam, and 150 kg for the slab. The analysis results are shown in Table 3. The highest work unit prices on the foundation, tie beam, and column components were seen in Aceh Tengah District, while for beam and slab components were seen in Gayo Lues District. Both districts are geographically located in the central region of Aceh Province and reside in areas with topographic forms dominated by hills or mountains. The lowest unit price for foundation components appeared in Aceh Tamiang District and for four other structural components appeared in South Aceh District.

### Table 2. The unit price for the reinforced concrete work components

| City/District | Unit Price (in thousand rupiah) | Concrete (per m$^3$) | Reinforcement (per 10 kg) | Formwork (per m$^3$) |
|---------------|---------------------------------|----------------------|---------------------------|----------------------|
|               | A.4.1.1.7                        | A.4.1.1.8            | A.4.1.1.9                  | A.4.1.1.10           |
|               | A.4.1.1.12                       | A.4.1.1.23           | A.4.1.1.24                 |                       |
| Banda Aceh    | 1,144                            | 1,165                | 1,201                      | 1,212                |
|               | A.4.1.17                         | A.4.1.18             | A.4.1.19                    | A.4.1.20              |
|               | A.4.1.1.10                        | A.4.1.1.12               | A.4.1.1.13                  | A.4.1.1.21             |
|               | A.4.1.1.23                       | A.4.1.1.24             |                           |                       |
| Sabang        | 1,171                            | 1,193                | 1,232                      | 1,244                |
| Aceh Besar    | 1,144                            | 1,165                | 1,201                      | 1,212                |
|               | A.4.1.17                         | A.4.1.18             | A.4.1.19                    | A.4.1.20              |
|               | A.4.1.1.10                        | A.4.1.1.12               | A.4.1.1.13                  | A.4.1.1.21             |
|               | A.4.1.1.23                       | A.4.1.1.24             |                           |                       |
| Pidie         | 1,124                            | 1,146                | 1,183                      | 1,195                |
| Pidie Jaya    | 1,108                            | 1,130                | 1,168                      | 1,179                |
| Bireun        | 1,102                            | 1,124                | 1,162                      | 1,173                |
| Bener Meriah  | 1,114                            | 1,136                | 1,172                      | 1,184                |
| Aceh Tengah   | 1,152                            | 1,175                | 1,214                      | 1,226                |
| Gayo Lues     | 1,159                            | 1,184                | 1,228                      | 1,241                |
| Aceh Tenggara | 1,157                            | 1,179                | 1,218                      | 1,230                |
| Lhokseumawe   | 1,084                            | 1,106                | 1,143                      | 1,154                |
| Aceh Utara    | 1,112                            | 1,133                | 1,170                      | 1,181                |
| Aceh Timur    | 1,132                            | 1,154                | 1,191                      | 1,202                |
| Langsa        | 1,201                            | 1,222                | 1,259                      | 1,270                |
| Aceh Tamiang  | 1,006                            | 1,027                | 1,064                      | 1,076                |
| Aceh Jaya     | 1,105                            | 1,127                | 1,164                      | 1,176                |
| Aceh Barat    | 1,038                            | 1,060                | 1,097                      | 1,109                |
| Nagan Raya    | 1,090                            | 1,111                | 1,148                      | 1,159                |
| Aceh Barat Daya | 1,090                     | 1,111                | 1,148                      | 1,159                |
| Aceh Selatan  | 1,134                            | 1,156                | 1,194                      | 1,206                |
| Subulussalam  | 1,163                            | 1,186                | 1,227                      | 1,239                |
| Aceh Singkil  | 1,252                            | 1,277                | 1,319                      | 1,332                |
| Simeulue      | 1,408                            | 1,437                | 1,486                      | 1,502                |

Min: 1,006 1,027 1,064 1,076 1,149 1,185 248 248 458 473 537
Max: 1,408 1,437 1,486 1,502 216 264 342 373 593 617 703
Table 3. The unit price for the reinforced concrete structure of the building

| City/District | Unit Price (in thousand rupiahs) | 6.28 | 6.29 | 6.30 | 6.31 | 6.32 |
|---------------|---------------------------------|------|------|------|------|------|
|               | (foundation)                    |      |      |      |      |      |
| Banda Aceh    | 5,200                           | 5,698| 7,271| 7,930| 7,916|      |
| Sabang        | 5,439                           | 5,969| 7,531| 7,987| 7,928|      |
| Aceh Besar    | 5,126                           | 5,596| 7,013| 7,535| 7,470|      |
| Pidie         | 5,267                           | 5,738| 7,099| 7,580| 7,477|      |
| Pidie Jaya    | 5,419                           | 5,900| 7,370| 7,873| 7,823|      |
| Bireun        | 5,636                           | 6,166| 7,898| 8,495| 8,535|      |
| Bener Meriah  | 5,630                           | 6,135| 7,708| 8,220| 8,203|      |
| Aceh Tengah   | 6,152                           | 6,681| 8,441| 8,913| 9,004|      |
| Gayo Luwes    | 5,955                           | 6,523| 8,385| 8,957| 9,017|      |
| Aceh Tenggara | 5,520                           | 6,099| 7,739| 8,247| 8,153|      |
| Lhokseumawe   | 5,343                           | 5,920| 7,690| 8,298| 8,280|      |
| Aceh Utara    | 5,344                           | 5,922| 7,629| 8,178| 8,117|      |
| Aceh Timur    | 5,262                           | 6,135| 7,708| 8,220| 8,203|      |
| Langsa        | 5,388                           | 5,964| 7,706| 8,355| 8,306|      |
| Aceh Tamiang  | 5,043                           | 5,570| 7,116| 7,651| 7,565|      |
| Aceh Jaya     | 5,179                           | 5,661| 7,193| 7,710| 7,696|      |
| Aceh Barat    | 5,295                           | 5,840| 7,493| 7,993| 7,971|      |
| Nagan Raya    | 5,278                           | 5,803| 7,423| 7,962| 7,939|      |
| Aceh Barat Daya | 5,174                         | 5,651| 7,177| 7,717| 7,709|      |
| Aceh Selatan  | 5,082                           | 5,511| 6,922| 7,384| 7,388|      |
| Subulussalam  | 5,212                           | 5,627| 7,144| 7,506| 7,629|      |
| Aceh Singkil  | 5,579                           | 6,046| 7,690| 8,143| 8,247|      |
| Simeulue      | 5,906                           | 6,348| 7,942| 8,389| 8,492|      |
| Min           | 5,043                           | 5,511| 6,922| 7,384| 7,388|      |
| Max           | 6,152                           | 6,681| 8,441| 8,957| 9,017|      |

3.2. The unit price pattern for reinforced concrete work components

The work unit price index is obtained based on the amount of the work unit price in each district/city reviewed in the previous section. The index is the ratio of prices in a city/district to prices in the area of reference. The value of 1.0000 is given as a price index in the city of Banda Aceh which is a reference for the price index in other districts/cities. The index values obtained can generally be categorised as ‘upper reference’ index (UPI > 1.000) and ‘below reference’ index (UPI < 1.000). The result of the index analysis of reinforced concrete work unit price based on job component is shown in Table 4, while the average index pattern provided in Figure 1.

For concrete work component, the unit price index in all cities/districts is positioned in the two categories. However, condition with index values is the same as reference areas appear for concrete work in Aceh Besar District. It occurs due to material prices and labour wages for these two regions are relatively the same. The highest index value for concrete work occurred in Simeulue District and the lowest in Aceh Tamiang District. Of all the areas analysed, eight cities/districts are included in the category of the area with the upper reference index, and 13 cities/districts are included in the category of the area with the below reference index. In general, cities/districts with the below reference index category are geographically located on the east/western coast of Aceh province, while cities/districts with upper reference index categories are located in the middle region or separate islands.
Table 4. The unit price index for the reinforced concrete work components

| City/District       | Unit Price Indices | Concrete (per m³) | Reinforcement (per 10 kg) | Formwork (per m²) |
|---------------------|--------------------|-------------------|---------------------------|-------------------|
|                     | A.4.1.1.7          | A.4.1.1.8         | A.4.1.1.9                  |
|                     |                    |                   | A.4.1.1.10                |
|                     | A.4.1.1.17a        | A.4.1.1.17b       | A.4.1.1.17c               |
| Banda Aceh          | 1.0000             | 1.0000            | 1.0000                    |
| Sabang              | 1.0231             | 1.0240            | 1.0254                    |
| Aceh Besar          | 1.0000             | 1.0000            | 1.0000                    |
| Pidie               | 0.9827             | 0.9837            | 0.9852                    |
| Pidie Jaya          | 0.9686             | 0.9700            | 0.9721                    |
| Bireun              | 0.9634             | 0.9648            | 0.9671                    |
| Bener Meriah        | 0.9740             | 0.9747            | 0.9758                    |
| Aceh Tengah         | 1.0073             | 1.0085            | 1.0105                    |
| Gayo Lues           | 1.0131             | 1.0166            | 1.0221                    |
| Aceh Tenggara       | 1.0111             | 1.0123            | 1.0141                    |
| Lhokseumawe         | 0.9478             | 0.9492            | 0.9514                    |
| Aceh Utara          | 0.9717             | 0.9725            | 0.9737                    |
| Aceh Timur          | 0.9893             | 0.9901            | 0.9913                    |
| Langsa              | 1.0499             | 1.0490            | 1.0477                    |
| Aceh Tamiang        | 0.8791             | 0.8818            | 0.8859                    |
| Aceh Jaya           | 0.9662             | 0.9674            | 0.9692                    |
| Aceh Barat          | 0.9071             | 0.9096            | 0.9134                    |
| Nagan Raya          | 0.9523             | 0.9536            | 0.9556                    |
| Aceh Barat Daya     | 0.9523             | 0.9556            | 0.9586                    |
| Aceh Selatan        | 0.9911             | 0.9923            | 0.9942                    |
| Subulussalam        | 1.0161             | 1.0181            | 1.0212                    |
| Aceh Singkil        | 1.0946             | 1.0960            | 1.0981                    |
| Simeulue            | 1.2309             | 1.2335            | 1.2375                    |

The highest index: 1.2309 0.8818 0.8859 0.8873 0.9216 0.9704 0.8289 0.8216 0.8494 0.8439 0.8644 1.1301
The lowest index: 0.8791 0.8818 0.8859 0.8873 0.9216 0.9704 0.8289 0.8216 0.8494 0.8439 0.8644

Figure 1. Reinforce concrete work index pattern
For reinforcement works, all the unit price indices are placed into the two categories. The highest index occurred in the district of Aceh Tengah, while the lowest index occurred in the district of Aceh Tamiang and Aceh Timur. In reinforcement work, generally, almost all cities/regencies are in the upper reference index category (74% for A.4.1.1.17a and 83% for A.4.1.1.17b), while the rest are in the category below reference index. Steel material for reinforcement is generally supplied from Medan City in North Sumatra Province. Cities or districts under below reference category is the closest regions to the supply centre of the material.

Related to formworks, the highest index of 5 types of formwork occurred in several areas, namely in Lhokseumawe City, Aceh Timur District, and Gayo Lues District, while the lowest index appeared in Subulussalam City and Pidie District. There are 9 to 11 cities/districts that are categorised below reference index, while the upper reference index categorises the rest. The characteristics of a location associated with the distance to the supplies sources can directly affect the price changes.

### 3.3. Unit price pattern for building structural component

The unit price index for building structural components demonstrate a particular pattern of changes in each region. The pattern of changes occurring at the structural component price index can be explained as a combined superposition of three unit prices consisting of the price of concrete, reinforcement, and formwork. The index changes in the cities/districts studied are shown in Table 5, and the pattern of index changes is illustrated in Figure 2.

| City/District | Unit Price Indices |
|---------------|--------------------|
|               | 6.28 (foundation)  | 6.29 (tie beam) | 6.30 (column) | 6.31 (beam) | 6.32 (slab) |
| Banda Aceh    | 1.0000             | 1.0000          | 1.0000        | 1.0000       | 1.0000       |
| Sabang        | 1.0460             | 1.0475          | 1.0358        | 1.0072       | 1.0015       |
| Aceh Besar    | 0.9858             | 0.9821          | 0.9645        | 0.9502       | 0.9437       |
| Pidie         | 1.0129             | 1.0071          | 0.9764        | 0.9559       | 0.9445       |
| Pidie Jaya    | 1.0420             | 1.0355          | 1.0137        | 0.9928       | 0.9882       |
| Bireun        | 1.0839             | 1.0822          | 1.0864        | 1.0712       | 1.0782       |
| Bener Meriah  | 1.0826             | 1.0768          | 1.0602        | 1.0366       | 1.0362       |
| Aceh Tengah   | 1.1832             | 1.1726          | 1.1616        | 1.1239       | 1.1375       |
| Gayo Lues     | 1.1451             | 1.1448          | 1.1533        | 1.1295       | 1.1391       |
| Aceh Tenggara | 1.0616             | 1.0704          | 1.0644        | 1.0400       | 1.0299       |
| Lhokseumawe   | 1.0275             | 1.0391          | 1.0577        | 1.0464       | 1.0460       |
| Aceh Utara    | 1.0277             | 1.0394          | 1.0494        | 1.0313       | 1.0254       |
| Aceh Timur    | 1.0120             | 1.0768          | 1.0602        | 1.0366       | 1.0362       |
| Langsa        | 1.0362             | 1.0467          | 1.0599        | 1.0536       | 1.0493       |
| Aceh Tamiang  | 0.9699             | 0.9776          | 0.9788        | 0.9648       | 0.9556       |
| Aceh Jaya     | 0.9961             | 0.9935          | 0.9893        | 0.9723       | 0.9723       |
| Aceh Barat    | 1.0183             | 1.0249          | 1.0306        | 1.0080       | 1.0069       |
| Nagan Raya    | 1.0149             | 1.0184          | 1.0209        | 1.0040       | 1.0030       |
| Aceh Barat Daya | 0.9950         | 0.9918          | 0.9871        | 0.9732       | 0.9738       |
| Aceh Selatan  | 0.9774             | 0.9672          | 0.9521        | 0.9311       | 0.9333       |
| Subulussalam  | 1.0024             | 0.9875          | 0.9826        | 0.9466       | 0.9638       |
| Aceh Singkil  | 1.0729             | 1.0611          | 1.0577        | 1.0269       | 1.0419       |
| Simeulue      | 1.1358             | 1.1140          | 1.0924        | 1.0579       | 1.0728       |
| The lowest index | 0.9699         | 0.9672          | 0.9521        | 0.9311       | 0.9333       |
| The highest index | 1.1832       | 1.1726          | 1.1616        | 1.1295       | 1.1391       |
The price index for the five structural components shows a tendency that majority of cities/districts reviewed (65% to 78%) are in the upper reference index category. These conditions illustrate the implications of the material and labour supply process for the completion of the works. When considered on the material aspect, materials are generally sourced from local production or materials trade in from other regions. Materials produced from the local area are generally in the form of aggregate materials for concrete work and wood materials for formwork work. Materials for reinforcement and other manufactured materials mostly must be imported from outside the province of Aceh, such as from the Province of North Sumatra or even from factories located in Java Island. The difference in the distribution distance between the material source and the location of the building becomes the factor causing the price difference material in each region. In view of labour aspects, construction labour generally comes from outside the province of Aceh, especially for labour in many government projects. The limitation of skilled labour in each region requires project implementers to recruit workers from outside with the consequence of increasing costs needed for the workforce mobilisation to each project location.

4. Conclusions
Changes that occur in the unit price of work have been studied using the object price unit of reinforced concrete work. This research makes a geographical factor of a region as the base in the study of price change which expressed in index form. Changes in unit price are seen from the side of change based on the components of reinforced concrete work and the structural components of a building.

Changes in the unit price index of work in each district/city in Aceh Province can be classified under the category reference index and the upper reference index. Index classification of the price of a region may vary by work types. Work in one region may be categorised as below reference index, while other works are considered in the category of the upper reference index. The price analysis process is done based on the standard that sets the same value of material and labour requirements, so the differences that arise are only related to the factor of material price change and labour wage in each region.

Implementation of price index information of work unit needs to be renewed, considering the extent of potential changes related to economic aspect in a region. The price index information will remain accurate and useful as a cost estimation guideline if within a specified period it is continuously adjusted to changes in material prices and labour costs. Changes in distribution patterns related to supply and demand will directly affect the rise or fall of its price.
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