The ratio of changes in construction costs and development index of the standard analysis of construction costs for state buildings

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Abstract. Wages rate and material price are an important part of a construction cost. The Construction Cost Index (CCI) that has been developed which applies to a certain area or period a basis for determining the bid price. This index is also very useful to forecasting construction cost which should reflect the comparison of wages rate and material price changes over time. Standard Construction Cost Analysis per m2 is one of the performance budget instruments to assess the budget of a construction project. Surabaya City Government applies that standard in set up government budget. SCC is composed of several Unit Price Analysis with a certain volume that design has been standardized. The composition of the labour and material price index, as a cost driver for Standar Construction Cost Analysis based on time units are expected to be used in the preparative of cost estimates for Building Construction and further research related to the effect of price increases on construction costs. The results obtained from this study are the construction cost change ratio in Surabaya for 2013-2016 increased average 17.3% per year; start from 2016 - 2020 increased not over 6.5% per year. Where as material cost change ratio tends to increase every year, except for 2014 - 2015 which has increase dramatically. In the other hand the labour price index indicate a constant increase because it was related to the Surabaya City Minimum Wage Rates, but in the early year in data (2013-2014) the Minimum Wage Rates significantly increased. In 2017-2018 labour cost change ratio increased more higher and material cost change ratio turn to decreased because the analysis used new guidelines for Analysis of Work Unit Prices for Public Works (Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia number 28/PRT/M/2016). The average component weight of the CCI according to the development of price are labour and foreman (41.3%), stone / brick (10.7%), roof truss and cover (10.4%), cement (8%), floor cover and paint (7.4%), wood (6.8%), iron bar (5.6%), accessories and complement (5.6%) and sand (4.2%). Material cost index tends to increase every year, except for 2018 and 2019 which has decreased. Whereas labour cost index indicated a constant increase because it was related to the UMK (City Minimum Wage) Surabaya. So that the CCI from 2013 to 2020 has increased from 1,00 to 1,93.

1. Introduction
The demand for material goods in an area is high if the economy of a region grows rapidly. Improper pricing policies can give the program negative affect [1]. The cost of a building can be very high if material and wages are imported from other regions. On the other hand when construction activities are low, competition is intense and construction companies are begining to bid on other regional markets [2].

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Construction costs are one of the main criteria for project success which is needed to supports the Good Government Programs. To avoid high costs, information about price from suppliers in Surabaya needs to be updated every year. Surabaya City Government has conducted a survey which is stated in Basic Unit Price of the Surabaya City Government every year. It is necessary for the contractor to get material prices and local wages in short term period [3].

Pricing can be based on the consumer price index that issued by BPS (Badan Pusat Statistik) every month. However, this index does not reflect actual construction costs because it is an aggregation of consumer goods groups that are largely unrelated to the construction process. Therefore a more specific cost index is needed. Fundamentally, Construction Cost Index (CCI) should reflect the comparison of price changes over time a fixed product [4]. This index is very useful to forecasting the cost of construction activities [5]. Construction costs are a crucial part of a construction project, the Construction Cost Index (CCI) has been developed which applies to a certain area or period. That index provides a base for determining bid prices.

Standard Construction Cost (SCC) is one of the performance-based budget instruments that have been publish since 2000 in Surabaya. SCC is one of the performance budget instruments to assess the budget amount of an activity. Most local governments in Indonesia have not implemented SCC in preparing their budgets. SCC is the standard cost of a program or activity so that the budget allocation becomes more rational. SCC is composed of several Unit Price Analysis with a certain volume that has been standardized by units per square meter of building.

Based on this background, it is necessary to conduct research on the development of wages rate and material prices as a support to compile a price index. Price index of building materials, wages rates, and building construction costs based on the time index. The time index is a comparison of the price of building materials, wages rates, and building construction costs from year to year. This preliminary research is carried out by collecting data on the prices of building materials and labour in Surabaya from 2013 to 2020 which form Standard Design Building State Type C. The material price and wages rate index and Building Cost Analysis based on time units are expected to be used in the estimate cost for building construction and further research related to the effect of price change on construction costs.

2. Methods
The data of this study are secondary data of Basic Unit Price material and wages of Surabaya City (e-budgeting) in the form of unit price analysis of building materials from 2013 to 2020 and wages rates from 2013 to 2020. Determination of material and wage rate requirements by processing data on work unit prices based on the Indonesian National Standard concerning procedures for calculating unit prices for relevant buildings and housing issued by the Indonesian National Standards Agency such as SNI 2835: 2008, SNI 2836: 2008, and SNI 2837: 2008 and Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia number 28 / PRT / M / 2016 concerning Guidelines for Analysis of Work Unit Prices for Public Works. In this study refers to the analysis that still refers to technical standards. Data were analyzed with a price index formula based on time index. The cost of building construction is taken from the Standard Construction Cost of Building which are issued by the Surabaya City Government from 2013 to 2020.

Estimated cost of building construction is carried out by taking one Construction Building Standard (Type C Building), then estimated prices in 2013 to 2020 and from the construction costs can be seen changes in prices for building construction projects each year.

This research began by Analysis of the Surabaya City Construction Cost Unit in e-budgeting program for state building construction work which was divided into 3 types of design standard, there are Type A, Type B and Type C. Then proceed to determine the material needs and wages of workers. There are 72 types of materials and 4 types of wages rate used to arrange Standard Construction Cost Type C.
Building. The next step is to collect data in the form of material prices and wages in the period of 2013 to 2018 using secondary data from the Development Administration Division of the Surabaya City Government. Then the materials and wages are carried out by processing data using the Indonesian National Standard concerning the procedure for calculating unit prices for buildings and housing.

2.1. Previous Research
The Construction Cost Index using Pratt Method [6],[7]. The research results index is limited to the total value of the building and has not reviewed the prices for each material and wages. Limit sensitive cost items in the city of Jakarta which is a component of the construction cost index. [8] Determination of the Construction Cost Index using building total cost more fully reflects the price index of the building. Furthermore, sensitive cost components are different between building types [6].

Many countries in Europe use Laspeyres Formula in forming the Cost Index [9]. The calculation of the Construction Cost Index by using the total value of the building is more representative of the index of a building, because all the material and wages are involved. So using the method automatically can also calculate the cost index of each material and wage.

Studied about the Construction Cost Index (CCI) in several countries in Europe [10]. This index is limited to 2 constituent elements, namely material costs and wages. The Construction Cost Index is calculated from the weights of material and wage in the base city. Material index and wages between regions are obtained using the Laspeyres formula which is the cost ratio between regions. From each of the material indexes and wages, a construction cost index can be calculated. The resulting index applies with the assumption that implementation and organizational techniques do not change, worker productivity tend to be the same between regions and there is no material or equipment change.

2.2. Price Index
The price index is defined as the price comparison rate at a time (a particular year) of the price at the time (year) used as a basis. Determining the price index based on time requires three variables, which is the price in a given year, the price in the base year, and the base year price index [11].

\[
\text{Price Index year } n : \frac{\text{price year } n}{\text{price of base year}} \times \text{price index of base year}
\]  

The price index of the base year is given a value of 100% or 1 (one) in the calculation of the price index, there are two factors that need to be considered in choosing the base year, there is the base year should be chosen in normal conditions and stable economic conditions or from the earliest data, because the base is 100% or 1 (one), the base year which is to be used as a basis for comparison is not too far from the year that is compared because if it is too far away it will cause some consequences that make the results doubtful [12].

2.3. Cost Weight
The total value of the building produced is then used to calculate the cost weight. The formula for calculating material and wage rate weight each year is as follows:

\[
w_{MT} = \frac{(V \times UMJ)}{TJ} \times 100 \%
\]

\[
w_{LT} = \frac{(V \times ULJ)}{TJ} \times 100 \%
\]

Where \(w_{MT}\) is material cost weights to the total cost of the building; \(w_{LT}\) is labour cost weights to the total cost of the building; \(V\) is volume; \(UMJ\) is material price per unit; \(ULJ\) is labour price per unit; and \(TJ\) is total building costs.
The formula to calculate the cost weight of each material against the total cost of the material in the base city and the cost weight of each wage to the total cost in the following basic year is the formula:

\[ w_{MM} = \frac{V \times UMJ}{TMJ} \times 100 \% \]  \hspace{1cm} (4)

\[ w_{LL} = \frac{V \times ULJ}{TLJ} \times 100 \% \]  \hspace{1cm} (5)

Where \( w_{MM} \) is material cost weights to total material costs; \( w_{LL} \) is labour cost weights to total labour costs; \( V \) is volume; \( UMJ \) is material price per unit; \( TMJ \) is total material costs; \( ULJ \) is labour price per unit; \( TLJ \) is total labour costs.

2.4. Cost Index
Material prices and wage rates are used to calculate an index of material costs and wage rates using the Laspeyres Formula [10]. Following is the formula of Material Cost Index and Labour Cost Index in year \( n \):

\[ IMA = \frac{UMA}{UMJ} \times 100 \]  \hspace{1cm} (6)

\[ ILA = \frac{ULA}{ULJ} \times 100 \]  \hspace{1cm} (7)

Where \( IMA \) is Material Cost Index per unit; \( UMA \) is Material Price per unit; \( UMJ \) is Material price per unit in the base year; \( ILA \) is Labour Cost Index per unit; \( ULA \) is Labour Price per unit; \( ULJ \) is Labour price per unit in the base year.

The weight of material items and wages in the base year, the material cost index and the wage cost index in the second year are used to construct the Construction Cost Index, namely the index of the total value of buildings in year \( n \).

\[ CCI = \sum (w_{MT} \times IM) + \sum (w_{LT} \times IL) \]  \hspace{1cm} (8)

Where \( CCI \) is Construction Cost Index; \( IM \) is Material Cost Index; \( IL \) is Labour Cost Index; \( w_{MT} \) is the cost weight of each material to the total cost in the base year; \( w_{LT} \) is the cost weight of each wage for the total cost in the base year.

The following is the formulation of the total material cost index and the index of total wage costs in year \( n \):

\[ MCI = \sum (w_{MM} \times IM) \]  \hspace{1cm} (9)

\[ LCI = \sum (w_{LL} \times IL) \]  \hspace{1cm} (10)

Where \( MCI \) is Material Cost Index; \( LCI \) is Labor Cost Index; \( w_{MM} \) is the cost weight of each material to the total material cost in the base year; \( w_{LL} \) is the cost weight of each wage for the total labour cost in the base year.

The total material cost index and the total wage cost index are used to see the difference in prices in the city of Surabaya each year.

3. Results
The total construction cost per m² for Type C Buildings in Surabaya City in 2020 is Rp6,053,612 - which includes the total material cost of Rp 3,100,303,- the total labour cost of Rp 2,953,309. Based on type C design standard, the recapitulation results of calculation and analysis of others construction cost/m² and construction cost change ratio can be seen in table 1.
Table 1. Construction cost/m2 and construction cost change ratio (year 2013-2020)

| Year | 2020       | 2019       | 2018       | 2017       | 2016       | 2015       | 2014       | 2013       |
|------|------------|------------|------------|------------|------------|------------|------------|------------|
| Labour Cost (Rp)/m² | 2,953,309  | 2,739,249  | 2,574,718  | 2,081,597  | 1,995,980  | 1,747,556  | 1,665,194  | 1,241,229  |
| Material Cost (Rp)/m² | 3,100,303  | 3,251,110  | 3,355,271  | 3,486,958  | 3,358,108  | 2,939,583  | 2,192,319  | 2,080,071  |
| Construction Cost (Rp)/m² | 6,053,612  | 5,990,359  | 5,929,989  | 5,568,555  | 5,354,088  | 4,687,139  | 3,857,513  | 3,321,300  |
| Labour Cost Change Ratio | 1.1%     | 1.0%     | 6.5%     | 4.0%     | 14.2%     | 21.5%     | 16.1%     |           |
| Material Cost Change Ratio | -4.6%    | -3.1%    | -3.8%    | 3.8%    | 14.2%    | 4.9%    | 34.2%    |           |

The recapitulation results of the standard analysis of building construction costs per m2 obtained the construction cost change ratio every year in Surabaya for 2013-2014 increased 16.1%; in 2014 – 2015 raised to 21.5%; in 2015 - 2016 amounted 14.2%; 2016 - 2017 by 4.0%; 2017-2018 increase 6.5%; 2018-2019 increased 1%; in 2019 – 2020 raised to 1.1%.

The calculation of the volume of work, analysis of material requirements and labour cost, and analysis of the unit price of the material group data and wages by recapitulation can be seen in table 2 and figure 1.

Table 2. Average component weight of the CCI according to the development of wage rates and material price

| Component                      | 2020 | 2019 | 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | Average |
|--------------------------------|------|------|------|------|------|------|------|------|---------|
| Labours Cost                   | 48.8%| 45.7%| 43.4%| 37.4%| 37.3%| 37.3%| 43.2%| 37.4%| 41.3%   |
| Foreman                        | 3.7% | 3.6% | 3.5% | 3.4% | 3.5% | 3.5% | 3.5% | 3.0% | 3.4%    |
| Labour                         | 45.0%| 42.1%| 39.9%| 34.0%| 33.8%| 34.3%| 39.7%| 34.4%| 37.9%   |
| Material Cost                  | 51.2%| 54.3%| 56.6%| 62.6%| 62.7%| 62.7%| 56.8%| 62.6%| 58.7%   |
| Stone Brick                    | 9.4% | 9.9% | 10.1%| 12.2%| 12.7%| 13.9%| 8.3% | 9.2% | 10.7%   |
| Roof Truss and Cover           | 12.7%| 10.9%| 10.8%| 12.1%| 12.4%| 7.8% | 7.8% | 8.5% | 10.4%   |
| Cement                         | 5.6% | 7.1% | 7.3% | 7.9% | 7.8% | 8.7% | 9.2% | 10.2%| 8.0%    |
| Wood                           | 5.7% | 6.3% | 6.1% | 6.9% | 6.8% | 7.3% | 7.1% | 8.5% | 6.8%    |
| Paint                          | 3.6% | 3.6% | 4.2% | 4.4% | 4.5% | 6.6% | 5.7% | 6.0% | 4.8%    |
| Iron Bar                       | 3.4% | 5.4% | 5.5% | 5.6% | 5.6% | 6.2% | 6.1% | 6.6% | 5.6%    |
| Sand                           | 3.7% | 4.1% | 4.4% | 4.6% | 4.1% | 3.9% | 4.2% | 4.6% | 4.2%    |
| Floor Cover                    | 1.8% | 2.0% | 2.6% | 2.8% | 2.8% | 2.7% | 3.0% | 3.1% | 2.6%    |
| Accessories                    | 2.5% | 2.4% | 2.5% | 2.7% | 2.6% | 2.2% | 2.2% | 2.3% | 2.4%    |
| Complement                     | 2.8% | 2.8% | 3.0% | 3.3% | 3.4% | 3.5% | 3.2% | 3.6% | 3.2%    |

Based on the results, the average component weight of the CCI according to the development of price are labour and foreman (41.3%), stone / brick (10.7%), roof truss and cover (10.4%), cement (8%), floor cover and paint (7.4%), wood (6.8%), iron bar (5.6%), accessories and complement (5.6%) and sand (4.2%).
Figure 1. Component weight of the Construction Cost Index (CCI) according to the development of wage rate and material price

Weight based on the total material value (wMM) or the total wage value (wLL) are useful to form a Construction Cost Index (CCI), Material Cost Index (MCI) and Labour Cost Index (LCI), recapitulation results can be shown in table 3 and table 4.

Table 3. Calculation of Material Price Index and Labour Price Index per component per year (2013-2020).

|                  | Year 2020 | 2019 | 2018 | 2017 | 2016 | 2015 | 2014 | 2013 |
|------------------|-----------|------|------|------|------|------|------|------|
| **Labours Cost** |           |      |      |      |      |      |      |      |
| Foreman          | 2.28      | 2.18 | 2.07 | 1.92 | 1.85 | 1.39 | 1.36 | 1.00 |
| Labour           | 2.39      | 2.21 | 2.07 | 1.66 | 1.59 | 1.41 | 1.34 | 1.00 |
| **Material Cost**|           |      |      |      |      |      |      |      |
| Cement           | 1.00      | 1.25 | 0.28 | 1.31 | 1.23 | 1.20 | 1.05 | 1.00 |
| Wood             | 1.21      | 1.34 | 1.29 | 1.37 | 1.29 | 1.21 | 0.97 | 1.00 |
| Floor Cover      | 1.07      | 1.14 | 1.49 | 1.48 | 1.42 | 1.23 | 1.13 | 1.00 |
| Paint            | 1.10      | 1.07 | 1.26 | 1.24 | 1.21 | 1.56 | 1.10 | 1.00 |
| Accessories      | 1.96      | 1.86 | 1.94 | 1.96 | 1.83 | 1.37 | 1.12 | 1.00 |
| Iron Bar         | 0.95      | 1.47 | 1.47 | 1.42 | 1.36 | 1.31 | 1.06 | 1.00 |
| Stone Brick      | 1.85      | 1.93 | 1.95 | 2.22 | 2.22 | 2.12 | 1.04 | 1.00 |
| Sand             | 1.49      | 1.60 | 1.73 | 1.68 | 1.45 | 1.19 | 1.05 | 1.00 |
| Roof Truss       | 2.73      | 2.28 | 2.24 | 2.31 | 2.28 | 1.25 | 1.05 | 1.00 |
| Roof Cover       | 2.73      | 2.50 | 2.50 | 2.91 | 2.81 | 1.58 | 1.18 | 1.00 |
| Miscellaneous    | 1.40      | 1.39 | 1.51 | 1.56 | 1.53 | 1.36 | 1.04 | 1.00 |
Table 4. Calculation of Construction Cost Index (CCI), Material Cost Index (MCI) and Labour Cost Index per year (2013-2020).

| Year | Construction Cost Index (CCI) | Labour Cost Index (LCI) | Material Cost Index (MCI) |
|------|-------------------------------|-------------------------|--------------------------|
| 2013 | 1.00                          | 1.00                    | 1.00                     |
| 2014 | 1.18                          | 1.34                    | 1.06                     |
| 2015 | 1.41                          | 1.41                    | 1.48                     |
| 2016 | 1.61                          | 1.61                    | 1.74                     |
| 2017 | 1.68                          | 1.68                    | 1.79                     |
| 2018 | 1.81                          | 2.07                    | 1.70                     |
| 2019 | 1.86                          | 2.21                    | 1.67                     |
| 2020 | 1.93                          | 2.38                    | 1.72                     |

Based on the table 4, by using 2013 as the base year with index = 1.00, it can be seen that the material cost index tends to increase every year, except for 2018 and 2019 which has decreased. Whereas labour cost index indicated a constant increase because it was related to the UMK (City Minimum Wage) Surabaya. So that the CCI from 2013 to 2020 has increased from 1.00 to 1.93.

4. Conclusion

Based on the result mentioned above, then obtained some conclusion namely:
1. The average component weight of the CCI according to the development of price are labour and foreman (41.3%), stone / brick (10.7%), roof truss and cover (10.4%), cement (8%), floor cover and paint (7.4%), wood (6.8%), iron bar (5.6%), accessories and complement (5.6%) and sand (4.2%).
2. The calculation of the standard analysis of building construction costs per m2 obtained the construction cost change ratio every year in Surabaya for 2013-2016 increased average 17.3% per year; start from 2016-2020 increased not over 6.5% per year.
3. Material cost index tends to increase every year, except for 2018 and 2019 which has decreased. Whereas labour cost index indicated a constant increase because it was related to the UMK (City Minimum Wage) Surabaya. So that the CCI from 2013 to 2020 has increased from 1.00 to 1.93.

References

[1] Deng et al. 2010 Economic Growth and the Expansion of Urban Land in China (Urban Studies) 47 4 813 – 34.
[2] Skitmore et al. 2006 Construction price formation: full-cost pricing or neoclassical microeconomic theory? Journal of Construction Management and Economics 24 7 773-83.
[3] Memon et al. 2010 Factor Affecting Construction Cost in Mara Large Construction Project : Perspective of Project Management Consultant International Journal of Sustainable Construction Engineering and Technology 1 2 41-54.
[4] Williams T P 1994 Predicting Changes in Construction Cost Indexes using Neural Networks Journal of Construction Engineering and Management 120(2) 306-20.
[5] Hwang S 2009 Dynamic Regression Models for Prediction of Construction Cost Journal of Construction Engineering and Management 135 360-75.
[6] Wibowo et al. 2013 Menuju Indeks Biaya Konstruksi Rumah Sejahtera Murah (IBK-RSM) Proceeding of Seminar Nasional IX-2013 Civil Engineering ITS, Surabaya.
[7] Pratt J W 1987 Dividing the Indivisible: Using Simple Symmetry to Partition Variance Explained Proceeding of the 2nd International Tampere Conference 245-60.
[8] Libianto et al. 2016 The Development of the Construction Cost Indices of Low-Cost Housing in Several Regions in Indonesia Media Teknik Sipil, ISSN 1693-3095 14 2 215-26 http://ejournal.umm.ac.id/index.php/jmts/article/view/3712
[9] Yu M K W and Ive G 2008 The Compilation Methods of Building Prices in Britain : a Critical Review *Journal of Construction and Economics* **26** 693-705.

[10] Eurostat 2006 *Methodology of Short-term Business Statistics : Interpretation and Guidelines.*

[11] Soeharto I 1997 *Manajemen Proyek Dari Konseptual Sampai Operasional* Erlangga, Jakarta.

[12] Santosa P *et al.* 2007 *Statistika Deskriptif dalam Bidang Ekonomi dan Niaga* Erlangga, Jakarta.